

FOREST REGIONS IN CHINA WITH SPECIAL  
REFERENCE TO THE NATURAL DISTRIBUTION  
OF PINES

BY

CHUNG-LWEN WU

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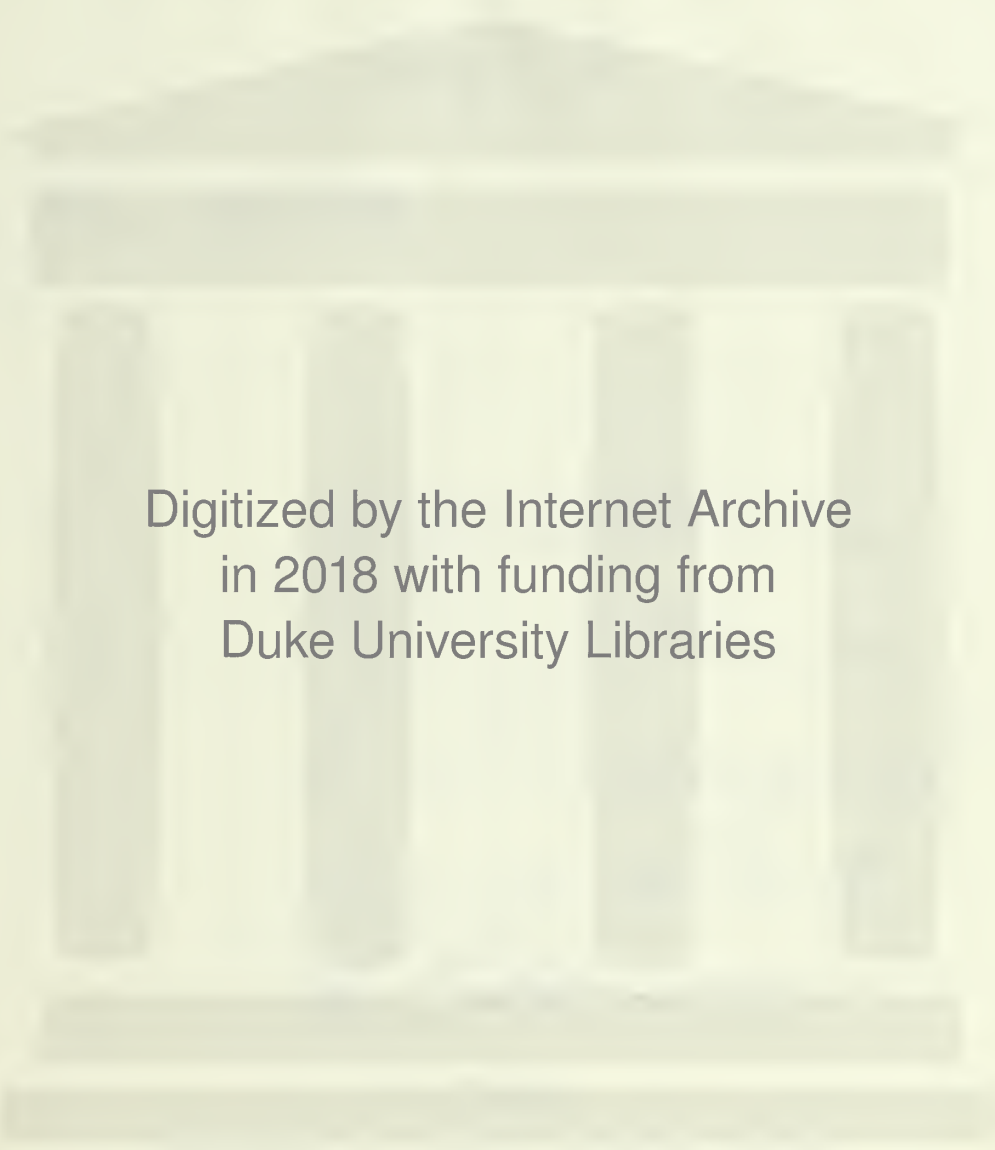
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by

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## CONTENTS

|                                                                             |    |
|-----------------------------------------------------------------------------|----|
| Introduction . . . . .                                                      | 2  |
| Literature Review. . . . .                                                  | 5  |
| Earlier Works Dealing with World Vegeta-<br>tion or Forests. . . . .        | 5  |
| Recent Works Concerning Chinese Vegeta-<br>tion or Floral Regions . . . . . | 7  |
| Recent Works Concerning Chinese Forest<br>Regions. . . . .                  | 12 |
| Review of Taxonomic Studies of Pines . . . .                                | 16 |
| Method of Determining Forest Regions . . . . .                              | 24 |
| Specific Ranges of Pines . . . . .                                          | 24 |
| Distribution of Other Forest Elements. . . .                                | 25 |
| Environmental Factors and Other Geographic<br>Characteristics. . . . .      | 26 |
| Regions Recognized and Named . . . . .                                      | 27 |
| Description of Environmental Conditions in<br>China. . . . .                | 30 |
| Location and Physiography. . . . .                                          | 30 |
| Climate. . . . .                                                            | 31 |
| Soils. . . . .                                                              | 36 |
| Human Activities . . . . .                                                  | 37 |
| Description of Forest Regions. . . . .                                      | 42 |
| The Northeast Boreal Mountain Forest . . . .                                | 42 |
| The Shantung Deciduous Forest. . . . .                                      | 46 |



## CONTENTS (Continued)

|                                                    |         |
|----------------------------------------------------|---------|
| The Central Mountain Mixed Forest. . . . .         | 49      |
| The Western Subalpine Boreal Forest. . . . .       | 55      |
| The Southwestern Subalpine Boreal Forest . . . . . | 58      |
| The Szechwan Basin Evergreen Forest. . . . .       | 67      |
| The Southern Yangtze Mixed Forest. . . . .         | 74      |
| The Southern Subtropical Monsoon Forest. . . . .   | 85      |
| The Yunnan Upland Monsoon Forest . . . . .         | 90      |
| The Hainan Subtropical Forest. . . . .             | 94      |
| The Taiwan Forest. . . . .                         | 97      |
| The Loess Upland Steppe and Woodland . . . . .     | 105     |
| <br>Description of Non-Forested Areas. . . . .     | <br>112 |
| The Northeastern Plain . . . . .                   | 112     |
| The Great Northern Plain . . . . .                 | 113     |
| The Yangtze River Lacustrine Plain . . . . .       | 114     |
| The Tibetan Alpine Tundra. . . . .                 | 115     |
| The Great Northwestern Grassland . . . . .         | 116     |
| The Sinkiang-Mongol Desert . . . . .               | 119     |
| <br>Discussion . . . . .                           | <br>121 |
| Summary. . . . .                                   | 128     |
| References Cited . . . . .                         | 135     |
| Map I. Forest Regions of China . . . . .           | 148     |



FOREST REGIONS IN CHINA WITH SPECIAL REFERENCE  
TO THE NATURAL DISTRIBUTION OF PINES



## INTRODUCTION

China comprises a vast territory with a wide diversity of physiographic, edaphic and climatic conditions. Consequently the vegetation is extremely varied, often complex, and, therefore, difficult to analyze and classify. This applies especially to the forest vegetation with which we are here concerned. Nevertheless, in order to approach an adequate understanding of the forest situation in China, an attempt must be made to work out some logical classification of its natural forest regions.

Properly recognized forest regions are the fundamental units upon which an effective administration of national forests and the establishment of regional experiment stations should be based.

Although there are a number of publications extant dealing with the different vegetation provinces or forest regions of China, none of these adequately present forest communities in relation to environmental factors. The majority are written from a floristic point of view and climatic conditions are mentioned briefly by only a few authors. Also, with one excep-





tion, the consideration of edaphic factors has been completely neglected.

The aim of the present study has been to work out a classification of the natural forest regions of China on the basis of the major natural forest communities together with a brief description of the respective environmental factors, such as climatic and soil conditions and human activities, for each recognized region.

Since 1933, the writer has traveled throughout most of eastern, southern, southwestern and northwestern China. He also discussed the classification of the natural forest regions in China from time to time with foresters and botanists who have made observations in the field.

Based upon a systematic study of Chinese pines, mostly in the Arnold Arboretum of Harvard University, and in the National Herbarium of the Smithsonian Institution, it was found that the natural distribution of pines is a quite reliable guide in recognizing forest regions in China. For South China, however, it was noted that three important bamboos, that is Sinocalamus affinis McClure, Sinocalamus latifolius McClure and Phyllostachys edulis Hook. are characteristic representatives for three regions in that part of the country.

In addition to field observations and systematic study of pines and their natural distribution used as the back bone of the present treatment, the available climatic data, and records of soil survey in China were studied in mapping the boundaries of the regions recognized. Most of the literature regarding



vegetation, especially in relation to forests, was reviewed, compared and cited in a discussion of important communities of the various regions. Other related literature, such as that dealing with physiography, geology, agriculture and travel notes, was studied in drawing the detailed boundaries.

It is hoped that the present treatment will give a more accurate picture of the Chinese forests and their environment. It should also be a useful reference to foresters in selecting species satisfactory for reforestation.



## LITERATURE REVIEW

### Earlier Works Dealing with World Vegetation or Forests

The forest regions in China were often briefly mentioned by earlier botanists and foresters who usually dealt with vegetation or forests of the whole world. Due to the extensive scope of their work, however, they gave only very broad divisions. Further, since information regarding vegetation and environmental factors was so meager in these earlier times, descriptions of regions were fragmentary and sometimes inaccurate. The boundaries set for each region were also vague and often arbitrary.

In 1898, Schimper published his famous, "Pflanzen-geographie auf physiologischer Grundlage." Although he gave fairly detailed descriptions of the important vegetation of the world, the discussion regarding Chinese vegetation was inadequate and fragmentary. The following outline of the vegetation of China is adapted from his map, "Distribution of the most important types of formations on the earth's surface":





1. Parklike landscape made up of forest and meadow; including most of Northeastern China.

2. Grassland as a climax formation and woodland as an edaphic formation; including a part of North China and Northeastern China.

3. Desert; including provinces north of the Loess-upland, Sinkiang and most of Mongolia.

4. Grassland; including the North China Plain and the Loess-upland.

5. Alpine desert; including Tibet, Tsinghai and their bordering areas.

6. Xerophilous woodland of tropical aspect; including almost the entire drainage region of the Yangtze River except its uppermost part, and a part of the Yunnan Plateau and the upper Sikiang Valley.

7. Less luxuriant rain-forest and particularly monsoon forest; including a narrow belt bordering the southern coast of Fukien and Kwangtung, southwestern Yunnan and two islands: Taiwan (also known as Formosa) and Hainan.

8. Luxuriant tropical rain forest and monsoon forest; including the westernmost Yunnan and the southern slopes of the Sikang-Tibet Plateau.

At the same time, Drude (1898) classified Chinese vegetation into four regions. The following outline is abstracted from his text with the scientific names revised according to present usage or concepts.





1. North Manchurian Vegetation-region. The characteristic trees for this region are: Juglans mandshurica Maxim., Pinus koraiensis Sieb. & Zucc, Pyrus ussuriensis Maxim., Corylus Sieboldiana var. mandschurica Schneid. and two species of maples.

2. North China Vegetation-region. The forests in this region are of boreal type. The characteristic trees are Paulownia tomentosa Steud., Gleditsia sinensis Lam., Catalpa Bungei C. A. Mey., Ailanthus altissima Swingle, Sophora japonica Linn. and Broussonetia papyrifera Vent. The high mountains in the west up to an elevation of 2,000 m. are covered by the same vegetation mentioned as above. But above 2,000 m. the mountains are densely clad with birches and hazels.

3. South China Vegetation-region. The mountains which might once have been covered by forest, are now dominated by chaparral consisting of numerous tree species. Forests are restricted to remote valleys only. Species of Camellia, Eurya, Lindera, Cinnamomum and the palm, Trachycarpus excelsa Wendl., Rhus verniciflua Stokes, Sapium sebiferum Roxb., Ginkgo biloba Linn., Cunninghamia lanceolata Hook., and Thuja orientalis Linn. are important representatives.

#### Recent Works Concerning Chinese Vegetation or Floral Regions

During the past few decades, intensive botanical collections have been carried on in botanical institutions in China. A knowledge of the flora of China has thus been accumulated. Based upon observation and specimens collected, several



phytogeographical classifications of China have been proposed. Since their bases are chiefly floristic, environmental factors are briefly considered or not mentioned at all. These works often contain a fairly long list of species occurring in each region. In some cases, the flora has been classified into a number of geographic components based upon the viewpoint of historical plant geography. A few such classifications will be concisely cited below:

So far as the Chinese flora is concerned, undoubtedly, Handel-Mazzetti (1926-36) was one of the outstanding authorities. Based upon his extensive knowledge, he proposed nine floral regions in China. In addition to floristic descriptions he also mentioned briefly some environmental factors. The nine regions he established are:

1. The mixed forest region of northeastern China and Korea,
2. The desert region of southern Gobi,
3. The steppe-region of the loess-land of North China,
4. The laurel region of central China and Japan,
5. Tropical China,
6. The upland and high mountains of Yunnan and West Szechwan,
7. The East Tibetan grassland,
8. The Monsoon region of Upper Burma and Yunnan and
9. The Tibetan Alpine Desert.

The phytogeographic division of China from an ecological point of view was first proposed by Chow and Chien (in Hu, 1933). However, this work has never been published but was briefly cited by Hu (1933) in his "The Geography of Plants."





The nine divisions proposed by Chow and Chien are:

1. The tropical tropophytic forest belt; including south-eastern Yunnan, Kwangtung, Kwangsi, Fukien and southern Chekiang and Hainan,
2. The tropical hydrophytic forest belt; including southern Tibet,
3. The temperate tropophytic forest belt; including Honan, Hupen, Kiangsi, Anhwei and northern Chekiang,
4. Narrow-leaved sclerophyllous forest belt; including southern Tsinghai, Sikang, Szechwan, Kweichow, Hunan, southern Kansu, most of Heilungkiang and eastern of Kirin and Liaoning,
5. Savannah; including most of Tsinghai, Shansi, Hopei, Shantung, northern Kiangsu and northwestern Mongolia,
6. Chaparral; including northwestern Yunnan, eastern Sikang (formerly western Szechwan),
7. Grassland; including borderland of Tsinghai, Sikang and Tibet, Sinkiang, outer and inner Mongolia, Shansi, northern Hopei, western Liaoning and Heilungkiang,
8. Desert; including the Great Gobi of Sinkiang and Mongolia, and the Ordos in Suiyuan, and
9. Alpine vegetation belt; including all high mountains above 3,000 m.

In 1936, Thorp in his "Geography of the Soils of China" proposed fifteen vegetational regions and five subregions for China. He did not, however, give definite names for the regions he proposed. The boundaries in his map are also too discontinuous and disperse. It is therefore impossible to make a



concise citation.

In 1940, Huang proposed the following twenty-six regions for the whole country, based chiefly upon Thorp's classification mentioned above: (1) Central Asiatic sandy desert, (2) Central Asiatic desert, (3) Short grass steppe, (4) Tall grass steppe, (5) Sinkiang-Mongolian mountain vegetation, (6) Tibetan high cold desert, (7) Sinkiang-Tsianghai high steppe, (8) Tsianghai tall and short grass mixed steppe, (9) Minshan grassland and woodland, (10) Himalayan mountain vegetation, (11) Southeastern Tibetan gorge vegetation, (12) Northeastern forest, (13) Northeastern steppe, (14) North China forest, (15) Loessland steppe, (16) Central China forest, (17) Southern China mountain forest, (18) Szechwan Basin forest, (19) Szechwan-Kweichow mountain forest, (20) Szechwan and Sikang borderland forest and steppe, (21) Yunnan Plateau forest, (22) Central Kwangtung and Kwangsi forest, (23) Hainan tropical vegetation, (24) Oasis, (25) Halophytes and (26) Alluvial plains.

Walker (1944) divided the whole country into ten floral regions as follows:

1. Northeastern China.
2. The Gobi Desert region of Mongolia.
3. The loess region covering eastern Kansu, most of Shensi and part of Shansi.
4. Middle China.
5. Tropical and subtropical southern China.
6. Southwestern Yunnan.
7. The highlands of western China.





8. The grassland of eastern Tibet, covering parts of Sikang, Tsinghai, and Kansu.

9. The northern plain or Chungtang in Tibet along with the Tsaidam, the part with internal drainage.

10. The outer plateau, the part of Tibet, drained by several rivers which flow in great gorges through the Himalayan Range.

In 1944, Li concluded that the Araliaceae may be appropriately used as the basis either of a divisional study of phytogeography or as a means of corroborating more general conclusions. In his "Phytogeographic Divisions of China, with Special Reference to the Araliaceae," fourteen phytogeographic regions are recognized:

1. The southern China Maritime.
2. The Tonkin Gulf.
3. The Mid-Mekong.
4. The Sino-Himalaya.
5. The southwestern China Plateau.
6. The upper Yangtze.
7. The middle lake.
8. The eastern China mountain.
9. The North China Plain.
10. The northern China Loess-highland.
11. The northeastern Chinese and Korean.
12. The Mongolian Desert-grassland.
13. The Sinkiang Basin.
14. The Tibetan Plateau.



## Recent Works Concerning Chinese Forest Regions

According to Mayr's classification (1925), Cheng (1941) proposed the following four major forest regions for the whole country:

1. Tropical forest region; including Hainan and coastal region of Kwangtung.
2. Subtropical forest region; including most part of the Yangtze River drainage.
3. Temperate forest region; including the area north of the Yangtze River.
4. Frigid forest region; including regions north of the Wutai Shan, the Northeast and Tibet.

In 1944, Hao proposed twelve vegetational regions for the country. From the twelve vegetational regions, he recognized six forest regions as follows:

1. Southern China region.
2. Central China region.
3. Manchurian region.
4. Khingan region.
5. Yunnan-Kweichow region.
6. Tien Shan and Altai Shan region.

Recently Teng (1948) recognized eighteen forest regions in China. They are: (1) Syansk-Altai region, (2) Tien Shan region, (3) Killien-Inshan region, (4) The Long White Mountains, (5) Khingan region, (6) Loess Highland region, (7) Tsingling-Tapa region, (8) Minshan region, (9) Northern Sikang region,





(10) Southern Sikang region, (11) Southeastern Sikang region, (12) Central Yunnan region, (13) Yangtze region, (14) South-eastern Maritime region, (15) Taiwan region, (16) Luichow-Hainan region, (17) Salween-Mekong region and (18) Tsangpo gorge region.

He grouped the forests of the above eighteen regions under the following seven formations: (1) Subboreal forest, (2) Sub-alpine forest, (3) Montane forest, (4) Deciduous forest, (5) Subtropical forest, (6) Tropical forest, and (7) Monsoon sub-alpine forest.

In addition to the phytogeographical and forest divisions mentioned above, several climatological classifications have been proposed. These works are quite suggestive to one who deals with ecological or forest divisions.

In 1930, Chu first issued his "Climatic Provinces of China" which has been widely cited in many papers and textbooks. In 1932, Chapman published his "Climatic Regions of China." But the most comprehensive treatment in connection with vegetation regions is Tu's "Climatic Provinces of China" which was issued in 1936. The following is an outline of climatic provinces proposed by Tu:

1. Manchuria type:

- a. Khingan Mountains: Boreal forests.
- b. Manchurian Plain: Cultivated farmland.
- c. The Long White Mountains: Pine forests.

2. Mongolian type:

- a. Desert.
- b. Desert steppe.





- c. Pasture steppe.
- d. Agriculture steppe.
- e. Boreal climate of the mountains.
- 3. North China type:
  - a. The Great Plain.
  - b. The Loess Plateau.
- 4. Central China type:
  - a. The lower Yangtze Valley.
  - b. Hangchow Gulf.
  - c. The middle Yangtze Valley.
  - d. The Szechwan Basin.
- 5. South China type:
  - a. Southeastern coast.
  - b. The Sikiang Valley.
  - c. Hainan.
- 6. West China type:
  - a. The Southwest Plateau.
  - b. The Sikang Mountains.
  - c. The Tsingling Ranges.
- 7. Tibetan type:
  - a. North Tibet.
  - b. South Tibet.
  - c. Tsinghai.
- 8. Southeastern Tibet type:

Recently Lu (1944, 1946) and Borchert (1947) proposed two new maps of Chinese climatic regions, based upon the accumulated climatological data in China. Both adopted and modified



Köppen's classification (~~1923~~, 1931) in their maps. Since only symbols were used, a direct citation is not practical for the present treatment.

To date, there are hundreds of reports describing Chinese vegetation and forests, but only a few can be considered as true ecological studies or forest investigations even from the standpoint of preliminary reconnaissance. Most of the reports are merely floristic enumerations or just travel notes. However, several of these reports are quite informative.

The true ecological study of Chinese vegetation was first started by S. S. Chien (1927, 1932a, 1932b), though all his investigations are preliminary observations.

From the standpoint of historical plant geography, H. H. Hu (1929a, 1929b, 1935, 1936, 1940) has contributed considerably to Chinese botany. He recognized eight phytogeographic components in China: (1) Circumpolar and palaearctic, (2) Central Asiatic, (3) Himalayan, (4) Indo-Himalayan, (5) Insular and Japanese, (6) North American, (7) Cosmopolitan, and (8) Endemic. His influence is so far reaching that many Chinese botanists frequently mention such floristic elements in their reports.

T. N. Liou (1930, 1934, 1941) has treated Chinese vegetation by means of phytosociological methods. He was the first botanist to use pines as phytogeographical representatives.

With reference to forest investigation, S. C. Teng's contributions (1939, 1947, 1948) are undoubtedly the most up-to-date and of highly technical value.





Other references describing local vegetation and forests will be cited under each forest region.

### Review of Taxonomic Studies of Pines

Of the Chinese pines, the first described species whose name is still valid is Pinus Massoniana Lamb. It was described by Lambert (1803) based upon a specimen brought to him by Francis Masson from the Cape of Good Hope, South Africa, where it was grown from seeds collected in China. In the same volume he described another Chinese pine, that is, Pinus sinensis Lamb., the description being based upon a Chinese drawing, supposed to represent the hard pine of North China. The name P. sinensis was generally accepted for the northern hard pine until 1926 when Rehder discovered that the drawing upon which P. sinensis was proposed, was identical with Pinus Massoniana. As a consequence, Pinus sinensis should be a synonym of Pinus Massoniana. Rehder (1926) then chose the name Pinus tabulaeformis Carr. as the correct name for the widely distributed northern hard pine.

With such meager information and insufficient material, the list of species has been enlarged slowly. The species were described by botanists all over the world and their original descriptions are scattered in various publications.

In 1904, Masters mentioned eight species of Chinese pines in his paper "A General Review of the Genus Pinus." They are Pinus scipioniformis Masters, P. koraiensis Sieb. et Zucc., P. Armandi Franch., P. Bungeana Zucc., P. Massoniana Lamb.,





P. Henryi Mast., P. yunnanensis Franch., and P. leucosperma Maxim. In 1906, Masters enumerated twelve species of pines in his paper "On the Conifers of China." In addition to the above species, he added P. densata Mast., P. prominens Mast., P. densiflora Sieb. & Zucc., P. luchuensis Meyr, and P. Mandshurica Rup., based on descriptions published after his 1903 paper.

In the first volume of Sargent's "Plantae Wilsonae" (1913) Shaw identified seven species of pines in the Wilson's collection from China, mostly from southwestern China. They are P. Armandi, P. Bungeana, P. Massoniana, P. densiflora, P. yunnanensis, P. densata and P. Wilsonii Shaw. He considered P. prominens as a synonym of P. densata. Under P. Armandi he added synonyms of P. scipioniformis and P. Mastersiana Hayate and P. Armandi var. Mastersiana Hayate. The last two names were actually based on the same specimen. The writer agrees with Shaw's classification except with respect to P. Armandi var. Mastersiana, which should be considered as a distinct variety. In the second volume of Sargent's "Plantae Wilsonae," however, Shaw revised his enumeration. He enlarged the specific conception of P. sinensis under which he lumped P. tabulaeformis Carr., P. leucosperma Maxim., P. densiflora Sieb. & Zucc. (Materials from China), P. Henryi Masters, P. Argyi Lemee & Leveille, P. nana Faurie & Lemee, P. canalerier Lemee & Leveille and P. Wilsonii Shaw as synonyms. He also reduced P. yunnanensis and P. densata to varieties of P. sinensis. Under var. densata he listed P. prominens as a synonym.

In 1930, Cheng issued "The Study on Chinese Pinus" in which he described five species and one variety as native of China,



namely P. Armandi, P. Bungeana, P. tabulaeformis, P. tabulaeformis var. densata, P. yunnanensis. In addition, he also briefly mentioned that P. koraiensis occurs in Manchuria, and P. Merkusii De Vries and P. insularis grow in the border of Yunnan. He agreed with Rehder's notion that Pinus tabulaeformis should be the valid name for the widely distributed northern hard pine as now generally accepted. Under P. tabulaeformis he likewise put a long list of synonyms.

The writer has examined the Chinese specimens in the Arnold Arboretum of Harvard University, in the United States National Herbarium of the Smithsonian Institution, in the New York Botanical Garden, and in the Herbarium of the University of California. As a result of this study a "Review of Chinese Pines" has been prepared in which fifteen species and eight varieties are given full description.<sup>1</sup> In addition, four species and one variety are mentioned without detailed discussion. In this revision three varieties were recognized under P. tabulaeformis, that is P. tabulaeformis var. leucosperma (Maxim.) Wu, P. tabulaeformis var. gracilifolia Wu and P. tabulaeformis var. pseudosylvestris Wu. P. Henryi Masters and P. densata Masters have been restored as separate species. P. prominens and P. Wilsonii have been considered as synonyms of P. densata. The writer has also established that P. densiflora is native in the Shantung Peninsula and its vicinity. Other

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1. Wu, C. L. A Review of Chinese Pines. Unpublished Manuscript.





synonyms listed by Shaw under P. sinensis have been discarded or included under other species. Among other revisions, it is interesting to note that P. yunnanensis Franch. has been found to be synonymous with P. insularis.

The following key and the respective regions of their occurrence will help to show the characteristics and distribution of pines in China.

#### Key and Distribution of Chinese Pines

- A. Leaves with one fibrovascular bundle; base of the bracts of leaf-fascicles not decurrent; basal sheath deciduous; wood soft . . . . . Subgen. I. Haploxylon
- B. Umbo of the cone-scales terminal; leaves in fascicles of 5.
- C. Seeds wingless.
  - D. Cones not readily dehiscent at maturity; spring shoots pubescent.
  - E. Cones large, 9-14 cm. long, the apophyses of cone-scales prolonged, spreading or reflex (Northeastern China). . . . . 1. P. koraiensis Sieb. & Zucc.
  - EE. Cones small, less than 5 cm. long, the apophyses of cone-scales appressed.
    - F. Apophyses glabrous; resin-ducts in leaf external. (high mountains of Northeastern China). . . . .  
 . . . . . 2. P. pumila Regl.
    - FF. Apophyses pubescent; resin-ducts in leaf medial. (borderland of Siberia and Manchuria) . . . . .  
 . . . . . 3. P. cembra var. siberica Loud.





DD. Cones dehiscent at maturity; spring shoots glabrous.

E. Apophyses straight or appressed. (central and western China). . .4. P. Armandi Franch.

EE. Apophyses more or less reflexed. (Taiwan) . . .  
. . . . .5. P. Armandi var.

Masteriana Hayata

CC. Seeds with a long effective wing.

D. Leaves slender, 12-18 cm. long. (S. W. Yunnan) . .  
. . . . .6. P. Wallichiana A. B. Jacks

DD. Leaves less than 7 cm. long.

E. Spring shoot pubescent; cone 5-6 cm. long.  
(Japan) . . . . .7. P. parviflora Sieb. & Zucc.

EE. Spring shoot glabrescent, cones 5-11 cm. long.  
(Taiwan). . . . .8. P. parviflora var.

morrisonicola Wu

EEE. Spring shoots glabrous, cone narrow, 6-7 cm.  
long. (Hainan and Mountains of S. China). . . .  
. . . . .9. P. parviflora var.

Fenzeliana Wu

BB. Umbo of the cone-scales dorsal; leaves in fascicles of

3. (Central China) . . . . 10. P. Bungeana Sieb.

AA. Leaves with two fibrovascular bundles; base of the bracts of  
leaf-fascicles decurrent; basal sheath persistent; wood  
hard . . . . . Subgen. II. Diploxylon.

B. Apophyses very thick, 1/2 or more as thick as wide . . .  
(SW. mountains). . . . .11. P. densata Mast.

BB. Apophyses flat or slightly thick, usually less than 1/3  
as wide.



- C. Fascicles ternate, occasionally with a few binate fascicles. (Yunnan Highland). . . . .  
 . . . . . 12. P. insularis Endl.
- CC. Fascicles binate; very rarely mixed with a few ternate fascicles.
- D. Resin ducts external, occasionally with one or two medial ducts at corner of the leaf-section.
- E. Leaves usually longer than 8 cm. rarely mixed with a few shorter ones; buds nonresinous.
- F. Apophyses of cone-scales flattened or occasionally slightly thickened; male catkins aggregated into a long cylindric spike up to 10 cm. long.
- G. Leaves slender 10-20 cm. long; cones nut brown. (S., SE. China). . . . .  
 . . . . . 13. P. Massoniana Lamb.
- GG. Leaves 5-12 cm. long; cone dull tawny yellow. (The Shantung peninsula). . . . .  
 . . . . . 14. P. densiflora Sieb. & Zucc.
- FF. Apophyses of cone-scales thickened; male catkins aggregated to a short spike.
- G. Cones small, 2.5-4 cm. long; umbo depressed or flattened. (mountains of central China)  
 . . . . . 15. P. Henryi Mast.
- GG. Cones above 5 cm. long; umbo mucronate or tuberculate. (P. tabulaeformis and the varieties).



- H. Leaves more or less rolled. (North China) . 16. P. tabulaeformis Carr.
- HH. Leaves glattened.
- I. Leaves short usually below 10 cm., not exceeding 15 cm.
- J. Leaves straight, 8-10 cm. long; cone-scales narrow, about 1 cm. wide. (Inner Mongolia) . . . . .
- . 17. P. tabulaeformis var. pseudosylvestris Wu
- JJ. Leaves more or less contorted; cone-scales about 1.5 cm. wide. (NW. China). . . . .
- . 18. P. tabulaeformis var. leucosperma Wu
- II. Leaves 11-18 cm. long. (NW. China) . . . . .
- . 19. P. tabulaeformis var. gracilifolia Wu
- EE. Leaves short usually 2-5 cm. long rarely up to 8 cm.; buds resinous. (Borderland of Northeastern China). . . . . 20. P. sylvestris Linn.
- DD. Resin ducts medial, rarely with one or two external ducts at ventral sides.
- E. Cones sessile, or stout-pedunculate, conical or ovoid; about as long as broad.
- F. Leaves about 6-20 cm. long. (Liuchiu and Taiwan). . . . 21. P. luchuensis Meyr





FF. Leaves 5-15 cm. long. (high mountains of south-eastern China) . . . . .

. . . . . 22. P. luchuensis var.

hwangshanensis Wu

EE. Cones slenderly pedunculate, narrow, much longer than broad. (Hainan). . . . .

. . . . . 23. P. Merkusii De Vries



## METHOD OF DETERMINING FOREST REGIONS

The forest regions proposed in this treatment are based chiefly upon major forest communities. For convenience, however, arbitrary boundaries are drawn especially in case of geographic isolations and fragmentary disjunctures. The following criteria are used in determining the boundaries.

### Specific Ranges of Pines

A study of the distribution of Chinese pines reveals that the ranges of certain species, especially the yellow pines, constitute fairly well delimited regions within which occur certain characteristic forest communities. Accordingly, the natural distribution of pines is used as an important guide in recognizing the forest regions.

There are a number of other reasons for using the natural distribution of pine in determining forest regions. First of all, pines are extremely tolerant to exposure, drought and eroded soils, and become established quickly anywhere on land that has been abandoned for one reason or another. This is



particularly important in a country that has been so long and so drastically deforested as China. Second, pines are so distinct that they can hardly be neglected by any investigators or collectors. As a consequence, more information is available regarding the distribution of pines than any other tree species. Finally, since pines are excellent pioneer species for reforestation, it is of advantage to silviculturists to know the specific range of pine as a guide to the natural forest regions.

The species of pine characteristic of the forest regions recognized will be enumerated in the following section. In addition, the natural distribution of pines and pine forests will be mentioned under each region separately.

#### Distribution of Other Forest Elements

The writer is well aware that it would be impossible to obtain an ideal division of natural forest regions for so vast and diverse an area as China, based exclusively upon the natural range of a single group of plants. Evidently South China together with Hainan and Taiwan, where Pinus Massoniana occurs, is far too extensive to be considered as one single region. The islands, Hainan and Taiwan are regarded as distinct regions because of their geographical isolation. On the mainland, within the range of this pine, three regions are recognized according to the natural occurrence of three common bamboos; that is Phyllostachys edulis A. & C. Riv., Sinocalamus affinis McClure and Sinocalamus latifolius McClure. These three bamboos





are so well suited to the climatic conditions of their own region, that they are excellent indicators for the three regions considered in South China. Moreover they are widely planted and of paramount economic importance in each respective region.

In describing each region other important tree species are, of course, considered. Species without ecological or forest importance will not be mentioned despite their floristic interest. Of minor associates in forest communities only those which contribute distinct characteristics to forests over a considerable area will be mentioned.

#### Environmental Factors and Other Geographic Characteristics

Climatic, edaphic and physiographic factors were all considered in drawing the detailed boundaries. A number of publications dealing with geographic divisions of China from different points of view were studied. The important contributions referred to in the present study are: "The Geography of Soils of China" by Thorp (1936, 1941), "The Agricultural Areas of China" by Buck (1937), "The Natural Provinces of China" by Lee (1939), "The Geographic Regions and Landforms of China" by Raiz (Cressey, 1944) and "The Geographic Regions of China" by Ho, Cheng and Cheng (1946).



## REGIONS RECOGNIZED AND NAMED

As a matter of fact, a forest is only one kind of a plant community. Over a large area, it is rarely possible that the plant communities are exclusively forest. On the other hand, with the exception of two circumpolar regions, there is no land surface of wide expanse without any woodlands. Even within a desert, there are scattered oases which are often covered with considerable amount of arborescent vegetation. In most cases, whether a place should be considered as forested or nonforested depends chiefly upon the extensiveness of the forest land in proportion to the nonforested area. Generally, the transition from desert to grassland and from grassland to woodlands is usually gradual. Therefore, it is impossible to give a complete picture of forest situations of a large country like China without mention of other types of vegetation.

In the present treatment, eighteen vegetation regions are recognized for the whole country. Of these twelve are considered as forest regions which are either mostly covered by forest or a considerable portion of the area should be devoted to forest plantations in order to maintain permanent and sound





land utilization.

These twelve regions are named from the major types of forest and qualified by the specific geographical locality. The following is a list of the forest regions recognized and the representative species of pine and bamboo for each region:

The Northeastern Boreal Mountain Forest Region . . . . .

. . . . . P. koraiensis

The Shantung Deciduous Forest Region . . . . .

. . . . . P. densiflora

The Central Mountain Mixed Forest Region . . . . .

. . . . . P. tabulaeformis, P. Bungeana, P. Henryi

The Western Subalpine Boreal Forest Region . . . . .

. . . . . P. tabulaeformis var. gracilifolia, P. tabulaeformis var. leucosperma

The Southwestern Mountain Forest Region. . . . .

. . . . . P. densata

The Szechwan Basin Evergreen Forest Region . . . . .

. . . . . P. Massoniana and Sinocalamus affinis

The Southern Youngtze Mixed Forest Region. . . . .

. . . . . P. Massoniana and Phyllostachys edulis

Subregion a. Southeastern Mountain Coniferous Forest. .

. . . . . P. luchuensis var. hwangshanensis

Subregion b. Southern Mountain Mixed Evergreen Forest .

. . . . . P. parviflora var. Fenzeliana

The Southern Subtropical Forest Region . . . . .

. . . . . P. Massoniana and Sinocalamus latifolius

The Yunnan Upland Monsoon Forest Region. . . . .

. . . . . P. insularis





The Hainan Subtropical Forest Region

The Tawan Forest Region

The Loess Upland Steppe and Woodland . . . . .

. . . . . P. tabulaeformis and P. tabulaeformis var.  
leucosperma

Of the eighteen vegetation regions recognized for the entire country, twelve are forested regions. The other six regions are nonforested areas. Three are cultivated plains: the Northeastern Plain, the Great Northern Plain, and the Yangtze River Lacustrine Plain. There are differing opinions concerning the original vegetation of these plains. Nevertheless, these plains will undoubtedly be used for farm practice unless our present agricultural science undergoes a radical revolution.

Actually the fifteen regions mentioned above occupy only about half of the country on the southeastern side. The other half is occupied by a lofty plateau and an enormous area of arid and semiarid land in the Great Northwest.

The lofty highland is named as the Tibetan Alpine Tundra, and the Great Northwest is subdivided into the Great Northwest Grassland and the Singkiang-Mongolian Desert.

The plains and other nonforested regions will be briefly mentioned in order to give a complete picture of Chinese vegetation. Besides, in both plains and grasslands, or even in desert areas, there are forests or woodlands either planted or naturally occurring in particular localities. Although forests in such regions are of limited area, they are of paramount importance either as watershed protection forests or farmstead woodlots.



## DESCRIPTION OF ENVIRONMENTAL CONDITIONS IN CHINA

### Location and Physiography

China embraces an expanse of landmass in eastern Asia, which is mostly located between latitude  $18^{\circ}$  N. to  $54^{\circ}$  N. (exactly  $53^{\circ} 52'$ ) and longitude  $70^{\circ}$  E. ( $70^{\circ} 21'$ ) to  $135^{\circ}$  E. ( $135^{\circ} 2' 30''$ ) except a group of islands "the Nansha Isles" (known to foreigners as Cap d' Amboine) which is lying astride latitude  $10^{\circ} 9.5'$  N. (Kuo, 1948). The total area of the country covers about 11,209,558 square kilometers (Ho et al, 1946) including Mongolia and the restored Taiwan.

In connection with the present relief, the landmass, as pointed out by Lee (1939) half encircles the stupendous massif of Tibet, forming a staircase that generally steps down toward the shelf-seas bordering the Pacific. The staircase does not, however, follow exactly the semi-circular arrangement, but is warped, distorted, shattered, and sculptured.

The whole country is very mountainous except a belt of plains bordering the eastern coast. According to Wong (in Ho et al, 1946) the percentage of different elevations and





configurations of the country is estimated to be as follows:

| <u>Altitude</u> | <u>Percentage</u> | <u>Topography</u> | <u>Percentage</u> |
|-----------------|-------------------|-------------------|-------------------|
| 0-500 m.        | 14                | Plains            | 10                |
| 500-1,000       | 18                | Basins            | 16                |
| 1,000-2,000     | 35                | Hills             | 9                 |
| 2,000-5,000     | 17                | Plateau           | 34                |
| 5,000 or over   | 16                | Mountains         | 30                |

### Climate

The climatic conditions are important environmental factors in controlling the distribution of tree species and forest communities. It is of particular importance in mapping the forest regions over so vast an area as China.

Among the climatic factors, air temperature and precipitation have been especially emphasized by ecologists and foresters in delimiting vegetation or forest regions. The data recording these two factors are now available from hundreds of stations (Academia Sinica, 1943, 1944) which are fairly uniformly distributed over the whole country except the Tibetan Plateau, the Northwest Desert and a few high mountains which are only sparsely populated and are hardly accessible. Based upon these climatological data, it is quite sufficient to give a general picture of climatic conditions in China for mapping forest regions.

After trying in different ways to analyze the available data, the conclusion is reached that no single climatic factor





or single set of factors may be used exclusively as a reliable criterion for determination of forest regions which should coincide with the natural range of important tree species or the major types of plant community. Nevertheless, the amount and distribution of annual precipitation is much emphasized here.

In connection with air temperature, mean temperature of January is very important as a criterion in fixing the boundaries of different regions. Obviously, except in the high mountains, the mean air temperatures of July is quite similar among all Chinese forest regions. Consequently, the methods used by Merriam (1894) and Mayr (1925) are nearly meaningless for China. For example, the mean temperature for the four hottest months at Hankow is about  $27^{\circ}$  C. and that at Canton  $28^{\circ}$  C. In accordance with Mayr's classification both places would belong to the zone of Palmetum. Actually this is not the case. As to Merriam's classification, the mean normal temperature for the six hottest weeks at each station was arbitrarily chosen in the mapping of life zones. The data of mean normal temperature for the six hottest weeks are not available. But if we use the mean temperature of July as the approximate substitute, it is easy to disprove Merriam's method ascertained by the fact that the mean temperature for July of Tientsin is almost the same as that of Canton.

Other climatic factors as rainfall-evaporation ratio, wind velocity and cloudiness of sky play an important role in limiting the vegetation. Since data of these factors are not available for most of China, only a general description based



upon available references, will be cited for each region.

In order to give an essential picture of the background of Chinese climatic conditions a brief account regarding the controlling geographic conditions seems highly advisable. In general, the climatic conditions in China are mainly determined by her geographical position in relation to the largest continent - Asia, the presence of the lofty Tibetan Plateau, and the west-east orientation of the majority of mountain ranges.

Eastern China has a similar climatic background to that of the eastern United States since both are located on the eastern coast of a great continent. Due to the larger land expanse of Asia, however, China suffers more severe winters because the extreme cold air mass spreads from the center of higher barometric pressure in the neighborhood of Irkutsk, Siberia. This cold air mass moves toward the ocean and sweeps along the eastern coast southward down to South China.

The following table shows the mean air temperature of January in cities of corresponding latitude in the United States and China. These cities are all located along the eastern coast and at low elevation.





| C H I N A        |                           |            | THE UNITED STATES |                           |            |
|------------------|---------------------------|------------|-------------------|---------------------------|------------|
| <u>City Name</u> | <u>lat.<sup>°</sup>N.</u> | <u>°C.</u> | <u>City Name</u>  | <u>lat.<sup>°</sup>N.</u> | <u>°C.</u> |
| Yenki            | 42:55                     | -14.0      | Boston, Mass.     | 42:15                     | -1.2       |
| Auton            | 40:09                     | -9.0       | New York, N. Y.   | 40.03                     | -.3        |
| Tientsin         | 39:07                     | -4.0       | Washington, D. C. | 38:54                     | 1.4        |
| Tsingtao         | 36:04                     | -1.4       | Portsmouth, Va.   | 36:47                     | 4.0        |
| Shanghai         | 31:12                     | 3.2        | Charleston, S. C. | 32:47                     | 10.0       |
| Foochow          | 25:59                     | 0.6        | Miami, Fla.       | 25:46                     | 20.1       |

During the winter, the Siberian cold air mass almost dominates the whole of China. However, Southwestern China, thanks to the protection given by a series of mountain ranges on the northern border, enjoys much milder winters, regardless of the fact that western China is farther away from the coast and on a higher elevation. The table on the following page shows this fact.

As to precipitation in China, it declines from south to north and from east to west. But in the southwestern provinces, the average precipitation is as much as or even higher than that of the coastal provinces. The cause of this is not definitely known. It may be due to the mountain complex which is believed to cause more rainfall.

More detailed descriptions and the essential data will be given under the discussion of each region. The factors which control the climatic conditions in each region are so complex that a detailed discussion is far beyond the scope of present work. However the conditions which apparently play a definite





# WESTERN CHINA

# EASTERN CHINA

| City Name | Lat.<br>N. | Alt.<br>(m) | Mean Air<br>temp. °C. | Extreme<br>Minimum<br>°C. |
|-----------|------------|-------------|-----------------------|---------------------------|
| Kwangyuan | 32°26'     | 511.9       | 6.7                   | -5.1                      |
| Chengtu   | 30°41'     | 503.1       | 5.5                   | -3.7                      |
| Ipin      | 28°40'     | 310.1       | 10.1                  | -1.6                      |
| Chinkiang | 32°13'     | 9.7         | 2.2                   | -12.8                     |
| Zo-ze     | 31°06'     | 100.0       | 3.4                   | -11.9                     |
| Wenling   | 28°30'     | 5.3         | 5.3                   | -7.2                      |



role in the local climate will be mentioned briefly.

The climatological data cited for this treatment were published mainly in two volumes, "Climatological Data - Temperature" (1944) and "Climatological Data - Precipitation," (1943) by the National Research Institute of Meteorology. Data used in the discussion for each region if not particularly noted are understood to be cited from these two volumes. Other references which give additional climatological information will be noted under each citation.

### Soils

The major groups of soils or zonal soils follow fairly well with the climatic regions. In China, however, the exceedingly rough mountainous countries in the west and the scattering young alluvial plains along the rivers give considerable intrazonal or azonal soils.

Speaking broadly, the soils of southern China are of pedalfer type, whereas those of the northern provinces are often of pedocal type. Only major types of soil will be mentioned for each region and there will be no detailed discussion of the characteristics of each soil type. Since the nomenclature of major soil groups has been well standardized, it will not be difficult to know the general property of soils in a region provided the major groups of soils have been enumerated.

As a matter of fact the study of soils in China, to date, has been much more concerned with the agricultural regions





(Thorp, 1936, 1941). Forest soils have been investigated only sporadically. Nevertheless in order to suit the present study, information regarding forest soils is particularly noticed.

### Human Activities

China has a very old civilization and a tremendously large population. Although she embraces a vast area, more than eleven million square kilometers, the arable plains occupy approximately only one tenth of her total territory (Hu, 1943). The continued, and intensive land utilization in order to obtain enough food-stuff for her people has, in consequence, drastically changed the natural vegetation, except in certain limited inaccessible mountainous localities, at high elevations and in deserts. Cressey (1934) stated: "Everywhere there are human beings. In this old, old land, one can scarcely find a spot unmodified by man and his activities. Whereas life has been profoundly influenced by the environment, it is equally true that man has reshaped and modified nature and given it a human stamp."

However, many travellers and foresters have fallaciously condemned the Chinese as universal forest destroyers. They also proclaim that China has been uniformly deforested, a statement based merely upon their limited observations which are usually confined to the vicinities of cities. It has been properly pointed out by Cressey (1944) that the popular conception of China as a deforested land is only partly correct. As to the course of deforestation in China, it is due to political





conditions rather than due to the will of the people. Actually most Chinese are indeed excellent foresters and soil conservationists. The now widely used terracing practice was first employed in China and is carried on intensively in most of the mountainous regions. Curran (Pendleton, 1937) after studying the photographic record taken by Pendleton from Kwangtung province wrote: "One may even say that the Chinese farmer of this region is perhaps among the most forest minded farmers of the world, since it is a common practice throughout the province to plant about the homestead and the farmstead, even though it be high in the hills, trees for fuel, fencing, home construction, and for export to the timber markets of the country." Pendleton (1937) also noted that the allegation that the Chinese are averse to the carrying on of any constructive forestry practice is not correct as shown by the production of bamboo and other forest products in many parts of China. Recently Nun (1946) traveled in Chekiang and noted: "It is seen that over some millions of acres of mountainous country, sound forest practice is being followed and there is every reason to believe that there is an approximation to sustained yield with age from 1 to 30 years and a selection system of silviculture. Soils erosion is practically non-existent in this region in spite of the steep slopes and high rainfall. This, without government or other centralized control, is almost incredible to a forester from overseas, but it is so." The forestry practice in Kweichow, Hunan and other southwestern provinces, except inaccessible subalpine regions, is even more intensive and more



carefully planned.

Nevertheless, in certain parts of China, the destructive exploitation on a considerable scale does proceed ruthlessly. Based upon extensive investigation in the southwestern and western mountainous regions, that kind of deforestation is really done by the beaurocratic capitalists and oppressive landlords. Only in a few places, forests are being encroached upon by farmers who have been crowded out from the fertile plains. Since they were formerly inhabitants of plains, they do not know how to make use of and to take care of the forest resources.

Generally speaking, the Great Northwest of China, which is considered as the cradle of Chinese civilization, is the most deforested and devegetated region. This is also the most difficult region to be revegetated because of the precarious rainfall. The devastation of this region also causes extremely serious floods and silting problems in the North China Plain.

The mountains and hills of Shantung, one of old civilization-centers, have also been so completely deforested, that it is difficult to believe that this region should be considered as natural forest land. Fortunately the successful reforestation in this area has been well demonstrated (Lampe, 1904).

In south China some places are well forested and others badly eroded. Thanks to the favorable climate, the reforestation in that region is not too difficult except on bare rocky slopes which unfortunately are quite extensive.

In southwestern China, especially the subalpine boreal forest region destructive forest exploitations are proceeding





at a menacing speed. Actually most of the forests there, as pointed out by Teng (1939), should logically be national property but have unfortunately passed into private possession. The so-called national forests in that region, do not include any forest tracts of considerable area.

In China, the most humid and subhumid regions are always densely populated. There are acute problems not only of food, but also of fuel resources. As a result, with the exception of certain inaccessible mountains, the undergrowth of forests has constantly been cleared up, if this is permitted. The collection of slash and even gathering litter is so intensely practiced that most of the forest floor is completely denuded. Contrary to the United States, it is not the problem of slash disposal but the problem of keeping an adequate amount of forest litter. By virtue of such constant clearance of undergrowth and litter, the mineral seed beds are always provided and the fire hazard is materially reduced. Probably, it is also true that the transitional type of forest such as pine stands can be readily maintained.

Forest fires are not so serious and widespread in China as in the United States. In densely populated areas the fire hazard has been materially reduced because so little slash and litter are left. In southwestern China, forests have been exploited very extensively and there is no slash disposal at all. Fortunately, the air humidity there is so high and rain falls so frequently that not only is a spontaneous fire impossible but it is even difficult to make a fire artificially





in the open. Forest fires do happen sporadically in north China, the southern coastal provinces and Yunnan. But the majority of the fires are set intentionally for the purpose of obtaining tender forage for grazing or to keep away wild animals which are an important menace to adjacent farmland.

It is noteworthy, that scattered over the country, there are numerous temples which are nearly always surrounded by small patches of semi-virgin forest. These relict forests are invaluable not only as resorts for visitors but also are ideal research centers of forest ecology and forest geography.



## DESCRIPTION OF FOREST REGIONS

### The Northeast Boreal Mountain Forest

Location and Physiography. The region embraces all the mountainous countries of the Northeast (known to foreigners as Manchuria). This region is enveloping a lowland known as the Northeastern Plain or the Manchurian Plain with a narrow opening toward south and a swampy gap toward the northeast.

The Long White Mountains or the Changpai Shan are located in the eastern part of the region. They run from northeast to southwest and descend gradually toward the Liaotung Peninsula. On the northeast it is bounded by the Ussuri River which serves as a natural demarcation between China and the Eastern Maritime Provinces of U.S.S.R. On the southeast the region is separated from Korea by the Duman and the Yalu Rivers. A contour line of an average elevation of 500 m. is regarded as a general dividing line of the region with the lowland plain.

In the north and west the Little Khingan and the Great Khingan Mountains form a gigantic pincers opening toward the plain. The Heilungkiang or the Amur River serves as an





international boundary between China and U.S.S.R. on the north and northwest. A contour line of 400 m. altitude is considered as the lower limit of the region. On the west the Great Khingan Mountains merge gradually into the Mongolian Steppe.

Most of the region is drained by the Soungari River in the north and the Liao River in the south. The Sungari River which separates the Long White Mountains and the Little Khingan Mountains, empties into the Heilungkiang or the Amur at the northeast.

Climate. This region has the coldest winter of all Chinese forest regions. The mean air temperature of January ranges from  $-20$  to  $-28^{\circ}$  C. Extreme minimum air temperature of the same month as low as  $-50^{\circ}$  C. has been recorded. On the other hand the summer is quite warm. The mean air temperature of July usually exceeds  $20^{\circ}$  C. The extreme maximum of July in this region, except on high altitudes, is almost as high as that of southern China. However, the summer here is very short. The growing season lasts about four to five months. (The growing season used in this paper is determined by means of the period when the monthly mean minimum air temperature is above  $6^{\circ}$  C. This is approximately  $43^{\circ}$  F. which was assumed by Merriam (1894) as marking the inception of the period of physiological activity in plants and of reproductive activity in animals.)

The annual precipitation ranges from 400 to 500 mm. This amount of rainfall is concentrated during the short growing season when more than 70 per cent of total precipitation falls. Snowfall is slight.



Winters are dry and fair. Destructive floods happen occasionally due to unusually rainy springs and early sudden melting of snow (Coville, 1933).

Soils. The soils in this region are predominantly podzols. In some places the characteristic A<sub>2</sub> horizon is well developed as mentioned by Pendleton in his report (1935) of Ach'eng clay loam. He mentioned that "the second or subsoil of this type is a medium gray, light gray, to nearly white, at times varying to a light yellowish or brownish color."

Baltz and Polynow (1930) mentioned that ground water podzolized soils caused by ground water were observed in northeastern and eastern Manchuria, especially along the Amur River.

In the southern part of the Long White Mountains, the Shantung brown soils prevail.

Distribution of Pines. Two species of pines have been found quite commonly in this region. Pinus koraiensis Sieb. & Zucc. occurs at lower altitudes. This pine either forms pure stands or is associated with fir in mixed forests. Pinus pumila Regel grows on high mountains near the timber line. On the western border of the Khingan Mountains, Pinus sylvestris var. siberica Loud. grows on sand dunes.

#### Types of Forests.

A. Coniferous Forest. This type of forest has been found extensively in the Long White Mountains at an elevation of 1,500-2,000 m. (Chen, 1934). The important species are: Abies nephrolepis Maxim. and Pinus koraiensis. These two





conifers either form pure stands or mixed forests. The density of the forest is fairly uniform if not disturbed. This type of forest also exists extensively in Korea (Wilson, 1919).

There are larch forests (Larix Gmelini Litvin.) in moist sites. But on drier spots larch is often mixed with birch.

There is little information regarding coniferous forests in the Khingan Mountains. Nevertheless, it was estimated that the Little and the Great Khingan Mountains occupy about two thirds of the total forest area, and contain about three fourths of the total volume of standing timber of the whole region (Shikata, 1937). Because of the greater difficulties in transportation, the forests here are not extensively exploited.

**B. Mixed Forest.** This is the most common type of forest, located at an elevation of 500 to 1,500 m. The forests consist of both conifers and hardwoods. The conifers as mentioned are pine and fir. The important deciduous trees are Quercus mongolica Turcz., Betula davurica Pall., B. mandshurica Nakai, Carpinus erosa Blume, Acer mono Maxim., A. mandshurica Maxim., A. barbinerves Maxim., A. tegmentosum Maxim., Fraxinus mandshurica Rupr., Tilia amurens Rupr., Ulmus lacinata Mayr., Ostryopsis Davidiana Dcne., Juglans mandshurica Maxim. and Populus koreana Rehd. (Kitagawa, 1937a, 1937b, 1937c; Kusnetzoff, 1892). Among the hardwood species, oaks and maples are the possible dominant elements in climax, whereas birches and poplars predominate in the successional forest.

The undergrowth is quite abundant. The common shrubs are





species of Corylus, Berberis, Deutzia, Philadelphus, Ribes, Spiraea, Euonymus, Rubus, Rhamnus, Lonicera, Lespedeza, Potentilla, and Rhododendron. There are also a number of ferns and other herbaceous plants.

C. Other Types of Plant Communities. Near the timber line there are dwarf woodlands consisting of Juniperus squamata Lamb. and Pinus pumila. They form open woodland and are intermingled with thickets composed of several species of shrubs.

Near bogs, swamps or rivers, groves of willows are common. The common willows are: Salix gracilistyla Miq. and S. viminalis Linn. Herbs are usually abundant in such wet places (Kitagawa, 1937c).

As mentioned above, toward the west of the Great Khingan Mountains, there are sand dunes which are densely covered by Pinus sylvestris var. siberica. The common shrubs in sand dunes are Ribes diacanthum Pall., Malus baccata Borkn. var. mandshurica Schneid., Prunus padus Linn., Crataegus sanguinea Pall., Caragana microphylla Lam. and Euonymus Bungeana Maxim. (Kitagawa, 1937a, 1937b).

### The Shantung Deciduous Forest

Location and Physiography. This region resembles that of the Great Northern Plain as far as the crops and way of life are concerned. But instead of being an alluvial plain, the region is a country of hills and mountains. This mountainous



region was once an island in the Yellow Sea but has now become half surrounded by the advancing delta of the Hwang River (Cressey, 1934).

The boundary of the region can be established by the present course of the Hwang River on the north, and one of the former courses on the south. On the west a strip of lakes is regarded as the natural boundary between this region and the adjacent plain.

The region is now nearly entirely deforested. But due to higher rainfall and rocky soils, it might have been once dominated by forest. This has been proved by the successful reforestation (Lampe, 1904). It is also established that a considerable portion of the region should be devoted to protection forest because of its rough topography, if erosion is to be avoided.

Numerous rivers directly empty into the sea but a few drain into the Taoshan lakes on the west.

Climate. The mean temperature of January is about  $0^{\circ}$  C. to  $-5^{\circ}$  C.; whereas that of July ranges from 25 to  $30^{\circ}$  C. Although it is near the coast, the annual range of the mean temperature is rather high as indicated above. Extreme minimum temperature as low as  $-20^{\circ}$  C. has been recorded in several places and below  $-15^{\circ}$  C. in the greater part of the region. The growing season is about seven to eight months long.

The annual precipitation is moderate and variable in different places. The location of the region relative to the





mountain ranges may be the chief factor in controlling the amount of rainfall in this region. Tsihsia, for example, which is located among a group of hills, has its average annual rainfall as low as 256.3 mm.; whereas Pashan receives an annual precipitation as high as 1,208.9 mm. The average annual precipitation ranges from 500 to 1,000 mm. About 70 per cent of the total annual rainfall occurs during the summer.

Soils. The region is mostly covered by Shantung brown soils, except certain lowlands where calcareous and saline alluvial soils predominate. Shantung brown soils are very closely related to gray-brown podzolic soils. But they are less developed in profile and nearly neutral or very slightly acid. In certain cases if the parent rock is calcareous or if the surface has been recalcified by being constantly covered with alkaline loess, they are more or less alkaline.

Distribution of Pines. Liou (1934) was first to find out that Pinus densiflora is an indigenous species in this region. This has been confirmed by specimens from the region and its vicinity. These specimens were previously misidentified as Pinus tabulaeformis. It is reported that this pine still plays an important role in the forests of Korea and the Liaotung Peninsula, where the lesser vegetation is very similar to that of this region (Liou, 1934).

Type of Forest. There is very little information about the natural vegetation and forests in this region. In fact all forests have been destroyed and even secondary growth is sparse.





In addition to Pinus densiflora, the present relict trees are Quercus variabilis Bl., Q. liaotungensis Koidz., Q. mongolica Turcz., Q. glandulifera Bl. and Ulmus pumila L. Pistacia chinensis Bge., Paulownia tomentosa Steud., Ailanthus altissima Swingle, Thuja orientalis L. and willows are commonly planted.

Judging from the climatic conditions, the climax vegetation of this region may be deciduous forest with oaks as dominants. However pine forest which should be considered as a successional formation, can linger on a long time or be quite permanently because of the scanty and uncertain precipitation, the steep slopes and stoney soils.

#### The Central Mountains Mixed Forest

Location and Physiography. The region may be considered as in many respects a transitional district between southern and northern China. With reference to vegetation, southern China is characterized by the natural distribution of bamboos which do not occur naturally in North China. In this region there are bamboos but they are small. Pedologically the soils of the region are mostly gray-brown podzolic soils which characterize moist South China. But in the northern border of the region, calcareous soils intrude in small patches.

This region is bounded on the north by the northern foothills of the Tsingling Ranges. On the east it is separated from the plains by a perimeter of mountain ranges. On the southeast the boundary with the Southern Yangtze Mixed Forest



is set by means of the demarcation between the gray-brown podzolic soils and yellow earths. On the western portion of the southern boundary, the region is distinguished by an average countour line of about 1,500 m. altitude.

This is a rugged country with mountain ranges usually oriented in the direction of east and west. A number of short streams drain the north slopes of the Tsingling Ranges and empty into the Weiho, a large tributary of the Yellow River. All drainage from the southern part of the range eventually reaches the Yangtze River. The Han River is the most important river which drains nearly all the southern slopes of the Tsingling Ranges and northern slopes of the Tapa Shan, including their eastern extensions. The Han River joins the Yangtze River at Hankow.

Climate. The mean air temperature of January near the northern limit may be slightly below zero, but in most of the region it rarely falls below freezing except on the high mountains. The mean air temperature of July ranges from 22 to 28° C. On high mountains, as shown in the data from Hwashan, the mean air temperature is about 18° C. The growing season is about seven to nine months long.

The annual precipitation ranges from 600 to 1,000 mm. Local variations of rainfall within the region are great because of orographic complexity. Most of the precipitation falls in summer and late spring.





Soils. The soils of the Tsingling Ranges have been investigated by Hou (Thorp & Hou, 1935). Three subzones may be distinguished in the region, as follows:

1. A northern semiarid zone is characterized by immature chestnut and light chestnut earths of loessal origin. The young soils are practically all calcareous. Residual soils are very rare.

2. A transitional subhumid zone is characterized by scattered forests of mixed nature, by the light grayish brown, slightly podzolized soils under forests, and by calcareous soils over massive limestone which are probably loessic in origin. Young soils of loessic nature are always associated with hard lime concretions (Schachiang which may be literally translated as "sand-ginger" corresponding to "ginger nuts" by the Russians). Residual soil materials are only mechanically weathered.

3. A southern normal, subhumid zone, is characterized by very dense, mixed forest on clayey or loamy textured mountain soils, by dark grayish brown to dark gray, slightly podzolized soils under forests, by non-calcareous soils over massive limestone, by the profound chemical weathering of granites. The few calcareous soils encountered in this region form narrow strips of alluvium along the rivers. Possibly, these may have been washed in from calcareous loess deposits which are very extensive south of the Tsingling Ranges.

The vertical zonation of soils in the mountains is here only slightly expressed. This is probably because active erosion and redeposition have obliterated most of the soil



differences that might otherwise occur.

Toward the south, within the region of the Tapa Shan and the Wu Shan, the gray-brown podzolic soils predominate. The soils have an acidic A<sub>0</sub> horizon of humus of mull type (pH 4.5). The humus is intermingled with dark brown silty loam with friable and granular structure. The podzolization is not well developed as only A<sub>0</sub>, A<sub>1</sub> and B horizons can be distinguished (Yu and Lee, 1945).

In case the underlying rocks are limestone or other calcareous rocks, brown earths have been observed, especially on steep slopes. This type of soil is originally developed under mixed forest. The intense erosion, following the destruction of the forest cover, removes the surface soils. The brown subsoils thus exposed usually show neutral or slightly alkaline reaction.

Distribution of Pines. There are four species of pines native to the region. They are Pinus tabulaeformis, P. Bungeana, P. Armandi and P. Henryi. Pinus tabulaeformis and P. Armandi are more important economically. The former often occupies exposed and drier sites whereas the latter dominates northern or moist slopes. Pinus tabulaeformis, as found in the western Tsingling Ranges, is very intolerant. The growth of young seedlings under canopy is almost negligible in comparison with those in the open. On the other hand Pinus Armandi is quite tolerant as indicated by the fairly vigorous growth of seedlings within the forest. This may imply that Pinus tabulaeformis is transitional in succession.





Another pine, Pinus Bungeana has also been found in this region (Purdome, 1913; Wilson, 1914). This pine is readily identified because of its strikingly chalky white bark. But it never forms extensive stands and the wood is brittle.

Toward the south on the borderland of Hupeh, Szechwan and Hunan, Pinus Henryi has been collected. Unfortunately there is no information regarding the forest value of this pine.

### Type of Forest.

A. Deciduous Hardwood Forest. This type of forest covers the majority of the region. Oaks, which are more tolerant, are dominant elements in the climax formation. The important species of oak are Quercus aliena Bl. var. acutiserrata Maxim., Q. glandulifera Bl., Q. liaotungensis Koidz., and Q. variabilis Bl. There are also birches (Betula mandshurica var. japonica Rehd., B. albo-sinensis Burk.) and poplars (Populus alba Linn., P. tremula Linn. var. Rockii Rehd. & Kobuski, P. Simonii Carr. (Pei, 1948). But birches and poplars are either minor elements in oak climax or predominate the transitional forest which occurs after the destruction of the climax forest. Apparently birches are more common on higher and drier sites, whereas poplars, except P. tremula var. Davidiana, usually grow at lower elevations or moist localities. Along rivers or in drained river basins, poplar frequently forms pure stands which may be considered as edaphic climax. Other minor elements in oak climax are maples (Acer Mono Maxim., A. longipes Rehd., A. robustum Pax., A. Maximowiczii Pax.), service berry





(Amelanchier asiatica Endl. var. sinica Schneid.) dogwood (Cornus controversa Hemsl.) and many other less important species. Populus tremula var. Davidiana often forms pure forest on exposed ridges. A dwarf oak (Quercus Baronii Skan.) is widely distributed on the northern slopes of the Tsingling Ranges. This oak is managed by coppice method and supplies very good fuelwood. It forms dense woods on steep slopes and is very effective in preventing landslides and soil erosion.

Toward the south, evergreen hardwoods occur as climax. Evergreen oaks and species of Lithocarpus and Castanopsis are the dominant members. After destruction of the evergreen hardwood, deciduous forest consisting chiefly of oaks invade. But here the oak forests are successional formations. They will be replaced by the more tolerant evergreen hardwood as succession continues.

B. Spruce and Fir Forests. On higher elevations (2,300 to 3,300 m.) within the region, spruce and fir forests are the climax vegetation (C.D.A.F., 1942; Wang & Mao, 1945). Apparently firs (Abies Fargesii Franch., A. chensiensis Van Tiegh.) are more abundant than spruces (Picea asperata Mast., P. neoveitchii Mast.). Still higher (above 3,000 m.) a species of larch (Larix Potaninii Batal.) has been found.

However, except possibly in the borderland of Szechuan and Hupei, there are few extensive fir and spruce forests. In the borderland of Szechwan and Hupei, fine fir forest has been reported by Wang and Mao (1945).



## The Western Subalpine Boreal Forest

Location and Physiography. The region is a mountainous country lying on the western border of the Loess Upland. Because of its higher altitude there is sufficient precipitation to support a forest vegetation in certain localities, but not quite enough to sustain forests everywhere in the region. The forests usually occupy a certain altitudinal zone. They sometimes form patches on northern slopes or in moist valleys.

The important drainage of the region is the upper Yellow River and its tributaries. In addition, there are a number of short rivers which disappear when they run into desert areas.

Climate. The climatic conditions of this region are similar to those of the Southwestern Mountain Forest. But the precipitation here is much lower.

Due to the higher altitude, it is fairly cool throughout the year. The mean air temperature of January is about  $-3$  to  $-5^{\circ}$  C. and that of July is  $18$  to  $20^{\circ}$  C. The extreme maximum of July may sometimes rise to about  $35^{\circ}$  C. The growing season is short, only about five months long.

The annual precipitation ranges from about 500 to 700 mm. Although Thorp and Hou (1935) pointed out that variations in precipitation are exceedingly localized, nowhere within the region has the annual precipitation been recorded as over 1,000 mm.

Hail storms are common (Rock, 1930). It is not so cloudy as its southern adjacent region. The scarcity of epiphytes





here indicates the lower air humidity. However, during winter clouds may hang lower and snow storms are severe.

Soils. The important soils under forests are the forest dark chestnut soils (Ma, 1938). Generally the depth of soil is about one meter. The reaction throughout the whole profile is alkaline. Nevertheless, the alkalinity increases with increase of depth. The horizons are well developed. Between the B and C horizons there is a whitish brown layer of carbonate accumulation with pH of about 8.4. Since the soils are re-calcified, the surface horizon consequently has a pH of about 7.5.

Soils below the forested belt are ordinary chestnut soils or light chestnut soils. It has been reported that soils under dense spruce forest are acidic forest brown soils but without mentioning the pH value and detailed characteristics (Hsu, 1944). There is little information about soils above the forested belt. They may be slightly developed rocky tundra.

Distribution of Pines. Within the region there are species of Pinus tabulaeformis and its varieties (P. tabulaeformis var. leucosperma and P. tabulaeformis var. gracilifolia) and P. Armandi. They either form pure stands or are mixed in spruce-fir forest. Sometimes the pines occur at the boundary of the timber line as park-like woodlands (Hao, 1938).

#### Types of Forest.

A. Spruce Forest. The climax forest and also the most important forest in the Killien Shan consists almost of pure



spruce (Picea asperata Mast.), with a few junipers (Juniperus tibetica Komar., J. saltuaria Rehd. & Wils.) as subordinates. The spruce forest occupies an altitudinal range from 2,500 to 3,500 m. (Hsu, 1944). On more dry and exposed places, junipers may predominate (Teng, 1947). Along water courses poplars form physiographic communities.

There is very little undergrowth, but once the forests are cut, they may be invaded by less tolerant trees such as birch and poplar (Cheo, 1940). But such successional communities will sooner or later be replaced by spruce which is evidently much more tolerant.

B. Spruce and Fir Forest. On the southern headwaters of the Yellow River, spruce (Picea asperata, P. neoveitchii, P. Wilsonii, P. purpurea Mast.) and fir (Abies sutchuensis Rehd. & Wils.) forests predominate (Cheo, 1941; Ku and Cheo, 1947; Chen & Chow, 1943; Chow, 1943, 1944; Ku, 1945; Teng, 1947; Rock, 1930). This climax vegetation of spruce and fir occupies a zone of 2,500 to 3,500 m. in altitude. There are dense undergrowths composed of Arundinaria spp. in the lower belt, and of Rhododendron spp. at higher elevations. The most important subordinates are birches (Betula albo-sinensis Burk., B. albo-sinensis var. sepenentrionalis Schneid., B. mandshurica var. japonica Rehd., B. Delavayi Franch.) and poplars (Pei, 1948). These deciduous hardwoods form transitional communities after the removal of fir and spruce. Larix Potanli occurs at higher elevations (about 3,000 to 3,400 m.) and scattered here and there on inaccessible cliffs and quite exposed rocky ridges





(Walker, 1941). The contrast of forested northern slopes and grassy or barren slopes on southern exposures is mostly distinct (Rock, 1930).

C. Deciduous Forests. At lower elevations (1,800 to 2,200 m.) of the southern upper Yellow River in Tsinghai and Kansu provinces, oaks (Quercus liaotungensis, Q. Baronii) and birches form mixed oak forests. There are also a number of subordinates as maples, hornbeams, and species of Fraxinus, Zelkova, Celtis and Tilia. In addition, the undergrowth is also abundant. In swamps or foothills, Rhododendron heaths are thick and common (Rock, 1930; Walker, 1941).

### The Southwestern Subalpine Boreal Forest

Location and Physiography. The region as pointed out by Rock (1925) is a vast conglomeration of peaks and mighty gorges with very little level ground. Although the lower limit for this region is set at an elevation of about 2,200 to 3,000 m., the deeply dissected gorges will not permit drawing an accurate boundary without extreme incisions. As the range of elevation within the region is very wide, ranging from 1,000 m. up to above 4,000 m., entirely different types of vegetations are consequently represented.

There are three important rivers which have their headwater in Tibet, and pass through this mountain and gorge country. They are the Salween, the Mekong and the Yangtze.

The Salween, flows for a long distance through Tibet proper





and then enters Yunnan on the west. In its southward course it becomes part of the Burmo-Siamese border and finally enters the Indian Ocean at Moulmein.

The Mekong parallels the Salween to about the 20th degree of latitude, then turns westward, and finally enters the tropical South China Sea near Saigon, Indo-China.

The Yangtze, the mightiest and longest of them all, is also the least consistent. It flows parallel to the Mekong to a point near Shiku, and thence makes a sharp curve, turning directly north; describes a huge loop, returns to the south, then turns to the east and at length bends to the northeast and enters the Pacific Ocean near Shanghai (Rock, 1926).

Climate. Since the region embraces a great altitudinal range, the climatic conditions are not homogeneous. The low gorges on the southern border may descend as low as 1,000 m. Such lowlands usually have a climate resembling that of the subtropics. On the other hand towering peaks and lofty ridges are numerous. The climate at these high altitudes resembles that of alpine tundra or even is similar to alpine arctic. One can encounter climate ranging from subtropic to arctic within a single day's trip.

Moreover, not only is the mountain complex deeply cut by gorges, but the rivers, and especially the upper Yangtze, often change their courses abruptly. As a consequence the local climatic variations become very prominent because of different elevations, exposures and direction of mountains. Places having the same altitude may have similar air temperature but their



air humidity and amount of precipitation often vary tremendously.

As a whole, the belt between 2,500 and 3,500 m. embraces the majority of the area. This is also the belt of greatest economic importance because of the magnificent spruce and fir forests growing here.

Climatological data from the region are meager. Fortunately the data available are from the spruce-fir forest-belt which is regarded as representative of the region.

Owing to the high altitude, the air temperature is low. The mean air temperature for July is about  $15^{\circ}$  C. which is the lowest for this month of all the forest regions in China. On the other hand the mean air temperature for January is about  $0^{\circ}$  to  $-5^{\circ}$  C. which is much higher than that of the same month in many other forest regions. The growing season ranges from four to seven months, depending upon altitude and latitude.

The annual precipitation ranges from 500 to 3,000 mm. (Lee, 1945). It has both local variation and annual fluctuation. The amount of precipitation is chiefly controlled by altitude, topography, and exposure. The directions of mountain ranges in relation to the prevailing direction of moisture laden winds play an important role in this connection. The altitude of 2,000 to 2,500 m. is found to be the belt of maximum precipitation in some places in this region (Hu, 1942). The precipitation is concentrated in the summer season.

Although winter has comparatively low precipitation, the relative humidity is high throughout the year. The monthly relative humidity varies from 75 to 90 per cent. In spruce and





fir forests of the southern Sikang, foggy, rainy and humid weather prevails throughout the growing season. Even where there is no rain, the heavy mist keeps all trees and shrubs dripping as if under constant spraying. In addition to such foggy mists, heavy showers also occur very often. It is nearly always impossible to work in those forests without getting wet. As a consequence, the fire hazard is very low. Snowfall is heavy in most of the region. A fierce snow blizzard occurred on May 6, 1929 according to Rock (1930b) in Chengtsi where firs grow.

Soils. Soils in this region are largely gray-brown podzolic soils, podzols and mountain meadow soils. Both gray-brown podzols and typical podzols are developed under forest cover. Since the podzolization intensifies with increase of altitude to a certain point where precipitation reaches its maximum, the gray-brown soils change gradually into podzols. Local microclimatic conditions, underlying rocks and vegetation also play an important role in evolving different soil types.

In general, the humus layers of podzols are often of the mor type, whereas those of gray-brown podzolic soils are of the mull type. However, the pH is not necessarily higher in those of podzols. It has been reported that the humus layers of podzols have a pH of 6.5-7; whereas those of gray-brown podzolic soils, 4-5.5 (Yu & Lee, 1945). But such fragmentary information should not be held as generally representative for the whole region.



Due to precipitous slopes in the region, the soils are often thin and rocky. The drainage as a whole is very good despite heavy rainfall.

Up to a certain elevation, the precipitation again decreases, and finally grasslands take the place of forests due either to insufficient precipitation or inadequate air temperature. As a consequence, mountain meadow soils gradually predominate. This type of soil is widely distributed over the higher mountains. In some cases, there is no B horizon in the profile (Yu & Lee, 1945).

Distribution of Pines. The representative species of pine for this region is Pinus densata. This pine occurs quite commonly throughout the region but nowhere forms extensive and dense stands. Other pines such as Pinus insularis and P. Armandi form pure stands or mixed forests in some deep valleys. Such sporadic occurrence of Pinus insularis and P. Armandi may be regarded as the outposts of their specific distribution. Toward the western border, Pinus excelsa has also been observed but only in scattered patches (Ward, 1916, 1927, 1935; Wang, 1939).

#### Types of Forest and Other Plant Communities.

A. Fir and Spruce Forests. The most important forest type in this region is composed of fir and spruce. Pure virgin stands of fir and spruce in various proportions exist extensively. These forests are undoubtedly of climax formation as indicated by the numerous seedlings of the same species which constitute





the overstory. Actually fir is far more important especially in humid localities and higher above 3,500 m. where pure fir forests predominate. Hemlocks (Tsuga yunnanensis Mast., T. chinensis Pritz.) sometimes also form pure forests but usually are mixed in forests of fir and spruce as codominants. Hemlocks extend further downward than spruce and fir and frequently become dominant along water courses. Larches are also found in small patches, and usually restricted along open streams or exposed moist slopes at higher altitudes up to 4,500 m. During the past decade, extensive observations of the forests in this region were made (Cheng, 1931, 1938; Yu, 1934, 1935; Chu, 1938; Chu, 1939; Teng, 1939; Chow, 1940; Pei, 1940; Wu, 1941; Hwang et al, 1943), but some investigators give exaggerated reports of the quantity and quality of the forests. It is true, however, that the region is very rich in floristic elements.

The most important species recorded in this type of forest are as follows:

|                                        |                |
|----------------------------------------|----------------|
| <u>Abies Fabri</u> Craib               | 2,600-4,000 m. |
| <u>Abies Delavayi</u> Fr.              | 2,800-3,300 m. |
| <u>Abies chenshanensis</u> Van Tiegh   | 2,800-4,000 m. |
| <u>Abies squamata</u> Mast.            | 3,300-4,600 m. |
| <u>Abies sutchuensis</u> Rehd. & Wils. | 2,600-3,600 m. |
| <u>Abies Forestii</u> Craib.           | 2,300-4,600 m. |
| <u>Abies recurvata</u> Mast.           | 2,300-3,800 m. |
| <u>Picea brachytyla</u> Pritz.         | 3,000-4,000 m. |
| <u>Picea likiangensis</u> Pritz.       | 2,800-4,000 m. |
| <u>Picea purpurea</u> Mast.            | 3,000-3,600 m. |





|                                 |                                |
|---------------------------------|--------------------------------|
| <u>Abies spectabilis</u> Spach. | 3,000-4,000 m. (Ward,<br>1935) |
| <u>Larix Potaninii</u> Batal    | 2,600-4,800 m.                 |
| <u>Larix Merrilliana</u> Wu     | 3,000-4,800 m.                 |
| <u>Larix Griffithii</u> Hook f. | 2,500-3,500 m.                 |
| <u>Tsuga chinensis</u> Pritz.   | 2,300-3,800 m.                 |
| <u>Tsuga yunnanensis</u> Mast.  | 2,600-4,000 m.                 |
| <u>Pinus densata</u> Mast.      | 2,500-3,500 m.                 |

The altitudinal distribution of each species listed above is based upon the field notes of specimens examined in different herbaria. Undoubtedly, nowhere else in the world can the timber line reach up to such a high altitude as in this region. The interwoven mountain conglomeration minimizes the effect of altitudinal increase.

In the fir and spruce forests, a number of hardwoods are present as subordinate associates. Birch (Betula albo-sinensis Burk.) sometimes even occupies a considerable per cent of the stand (Rock, 1930). Other common hardwoods are maples, wild apples, wild cherries, hazels and basswoods.

Except near the northern border, undergrowth is extremely abundant. On higher elevations, species of Rhododendron often form a closely interwoven undergrowth; whereas at lower elevations, small bamboos (Arundinaria spp.) grow so thick that it is almost impenetrable in most places. Species of Rubus, Smilax, Hydrangea, Stachyurus, Lonicera, Symplocos and Eurya are also common elements in the undergrowth.

There are also sphagnums which form rather thick mats in depressions. Mosses not only form dense ground-cover every-



where, but also such places may be very rich in species (Wu, 1941). Since the dense undergrowth and the thick forest floor prevent the tree seeds from contacting the mineral soils, the regeneration is, in consequence, very difficult.

On exposed slopes, Usnea longissima, hanging over tree crowns, gives a peculiar appearance, similar to Spanish moss in the southeastern United States. In very humid localities, epiphytes are extremely abundant. They consist of mosses, small ferns and tiny shrubs (Wu, 1941).

The prevailing logging practice carried on in this region is very destructive and without any conscious efforts to encourage regeneration. Stands once cut, eventually become a deteriorated jungle composed of numerous species of hardwood. On account of the extremely rugged topography as well as the frequent and torrential showers, wholesale landslides follow such wanton destruction. The succession from hardwood jungle to the spruce and fir climax is very slow although spruce and fir are undoubtedly more tolerant.

As pointed out by Teng (1939), the major forested area occupies steep slopes and should be considered as protection forest. Although he noted this for the Hunba forest, it is almost universally true for most of the region.

On the other hand the forests which have not yet been exploited or only slightly culled, are overmature and deteriorating. Decay becomes common when trees reach 60 cm. d.b.h. (Teng, 1939).





B. Evergreen Hardwood Forests. In lower altitudes of this region the climax formations should be evergreen hardwood associations. After the destruction of the evergreen hardwood, deciduous hardwoods usually follow. But if there is no further disturbance, the more tolerant evergreen hardwoods will sooner or later replace the deciduous forest. Species such as Lithocarpus cleistocarpa Rehd. & Wils., L. viridis Rehd. & Wils. and Quercus semicarpifolia Seem. ascend to a very high altitude. It has been reported growing at elevations as high as 4,600 m. However, it is at lower elevations (up to 2,500 m.) where extensive evergreen hardwood forests are found. They usually consist of species of Fagaceae and Lauraceae in mixed forests. Schima spp. and evergreen members of Magnoliaceae are also common.

Chinese foresters influenced by Mayr (1925) have often described a zone of deciduous forest between the zones of broad-leaved evergreen forest and boreal coniferous forest. As a matter of fact, for the most part, where the forest has not been disturbed, there is no such zone of deciduous forest (as named by Mayr, Fagetum and Castanetum). The evergreen hardwood forest (corresponding to Lauretum in Mayr's system) ascends to a fairly high altitude and then is directly succeeded upward by spruce and fir forest (or Picetum and Abietum). Sometimes hemlock appears before the occurrence of spruce and fir. The absence of a deciduous belt in this region may be attributed to the relatively high humid winters and cool summers. The evergreen hardwood can withstand the cool humid winter and



enjoys the advantage of quick resumption of photosyntheses when the growing season comes. The cool and short growing period seems not quite suitable for deciduous trees.

C. Juniperus and Rhododendron Woodlands. Near timber line (about 3,000 m. on isolated summits and northern border and 4,000 m. in continuous mountain ranges) woodlands consisting of dwarf trees occupy a narrow belt just below the tundra vegetation. Several species of Juniperus (J. tibetica Komarov, J. Potaninii Komarov, J. ramulosa Florin) and a large number of Rhododendron species are important elements in dwarf woodlands. Such woodlands often form park-like stands and are intermingled with grassland. Species of Lonicera, Ribes, Rosa and Potentilla fruticosa Linn. are the common associates.

D. Alpine tundra. This type of vegetation occupies a narrow belt between the timber line and everlasting snow. In case the slopes ascend gradually a belt of grassland exists.

This type of vegetation is composed of grasses and a goodly number of cushion herbs which sometimes attain dimensions up to one meter in diameter. Some isolated mountain summits, if not too high to be snow-clad, are often densely masked by dwarf rhododendrons only a few centimeters tall.

### The Szechwan Basin Evergreen Forest

Location and Physiography. This is a region widely known to geologists as the Red Basin, a name proposed by von Richtofen





because of its underlying purple shales and sandstones. Since the rocks are actually purple instead of red, as are also the soils developed from them, the name "red basin" is not used here. The region includes the greater part of Szechwan and a part of Kweichow.

The northern boundary of this region is drawn by a contour line of about 1,000 m. altitude, separating the region from the Central Mountains Mixed Forest. Westward a contour line of about 2,000 m. in altitude is used to separate the region from the Southwestern Mountain Forest. On the southwestern border the demarcation is set by the meeting belt of Pinus Massoniana and P. insularis. The boundary between this region and the Southern Yangtze Mixed Forest is set in accordance with the margin of the natural range of Sinocalamus affinis.

The basin is actually a land of rolling mountains and hills, except the Chengtu plain in the west. The Chengtu plain is the alluvial plain of the Min River with an area of 4,420 square kilometers. Elsewhere the region is generally under 700 meters in altitude.

The name Szechwan means "four rivers." These are the Min which enters the Yangtze at Ipin, the Tao at Luchow, the Chialing and the Chien from Kweichow. The first three rivers drain from the north and the last starts from the south.

Climate. This is an area of mild temperature next only to the region of the Yunnan Upland Monsoon Forest. The mean air temperature for January is always above 5° C. and that of July





only slightly exceeds  $25^{\circ}$  C. in most places. In certain river gorges, hot summer temperatures as high as  $38^{\circ}$  C. are not uncommon. On account of high relative humidity, such mountain gorges are really oppressively hot. The growing season lasts from 11 to 12 months.

The annual precipitation amounts to about 1,000 mm. and is fairly uniform throughout the whole region. The precipitation is most abundant in late spring and summer when about 80 per cent of the total occurs. Although the amount of precipitation during fall and winter is rather low, yet it is not a dry season. On the contrary, it is quite humid since gray clouds nearly always hang over the sky and a dense fog frequently envelops the country for the greater part of the winter. In addition, drizzling rains are also common (Lee, 1940). In Chengtu, for example, December has only 9.7 mm. rainfall, which is the lowest monthly precipitation. But in the same month the average relative humidity reaches 84 per cent, the highest for the year (Liu, 1941).

The region has a large amount of cloudiness and high humidities. In Chungking, for instance, the monthly average value of cloudiness ranges from 5.6 to 8.4. The monthly average relative humidity in Chungking ranges from 69 to 87 per cent (Yu & Lee, 1945).

Snow is of only occasional occurrence and of negligible depth in the lowlands. But the towering peaks are usually clad with snow for a considerable period of the winter.



Soils. Purple soils cover most of the region. Since they are young soils, their nature and acidity are largely dependent upon the underlying rocks. Both neutral and alkaline purple soils are equally extensive. The neutral purple soils which are developed from neutral or calcareous purple shales, cover most of the eastern portion of the region. They contain about one per cent of carbonate and have a pH of 6.5 to 7.5. The alkaline purple soils occupy the northern and central part. This type of soil is developed from calcareous rocks which contain 56 per cent of carbonates. The pH of the soils is about 7.5. In addition, in the western corner, there is a scattered occurrence of acidic soils which do not show carbonate reaction and have a pH below 6.5 (Yu & Lee, 1945).

The soils in this region are universally thin except in the foothills or depressions where yellow earths prevail. Around Chengtu plain there are alluvial paddy soils, which are of high fertility and are devoted entirely to agriculture.

In the southern part of the region, yellow earths become more common. Podzolic yellow earths are also widely distributed near the eastern border.

Distribution of Pine and Bamboos. This region is recognized by the occurrence of Pinus Massoniana and Sinocalamus affinis. But in case of alkaline purple soils, pine is replaced by Cupressus funebris Endl.

Pinus Massoniana is the most important tree growing in most of the mountainous country. It regenerates naturally on dry and exposed slopes. Pure pine plantations are very common





occurring usually in small patches. In the eastern portion of the region, this pine is frequently infected by Cronartium quercuum Miyabe, especially when growing in mixture with oaks. Although pine forest may be transitional in succession, most stands observed are quite stable, particularly on rocky slopes.

As to bamboo, Sinocalamus affinis characterizes the region very well. This bamboo sends out its young shoot during early autumn which is usually preceded by a rainy summer. The growth of this bamboo is not so rapid as that of Phyllostachys edulis. It takes about two to three months for Sinocalamus affinis to complete its height growth. The cool humid autumn is quite satisfactory to accomplish such growth. Although this bamboo does not become hardened before winter, the mild and humid weather does little harm to the tender culms. Sinocalamus affinis is so widely and abundantly planted around farmsteads which are dotted throughout the basin, that it gives the region a very distinct feature. On more dry and exposed places Bambusa rigida Keng & f. becomes important. These two bamboos are so similar in appearance that they can not be distinguished without close observation.

As a matter of fact, within the region there are certain localities where Phyllostachys edulis, a representative of the Southern Yangtze Mixed Forest, does occur. But they are only of local importance. In some places as in the neighborhood of Chungking, Phyllostachys edulis grows, but not vigorously. Phyllostachys edulis also grows in the southern and southwestern part of the region, where the warm summer temperature and higher



spring rainfall make possible a strip of outposts of this bamboo.

Types of Forest. Judging from climatic conditions the original or the possible natural climax vegetation might have been evergreen broadleaved forests. In the past, even places now covered by alkaline purple soils, might once have been covered by broadleaved forests and the soils were more or less podzolized. The forest types in this region may be mentioned as follows:

A. Evergreen Broadleaved Forests. This type of forest has mostly been disturbed. There are only a few remnants around temples or in certain relatively inaccessible localities. Even such relict stands have been modified and are actually secondary growth. The important species in the lowland are Phoebe Bournii Young, P.Chienii Cheng, Castanopsis Carlesii Chun, Machilus spp., Quercus glauca Thunb., Q. myrsinifolia Bl., Acer Fabri Hance, A. lavigatum Wall. and Cinnamomum spp. On higher elevations, Schima crenata Korth., Lithocarpus viridis Rehd. & Wils., L. cleistocarpa Rehd. & Wils., Castanopsis platycantha Rehd. & Wils., C. hystrix DC. are common.

B. Deciduous Forest. This may be the transitional stage leading toward the evergreen hardwood forest, because the latter is composed of more tolerant species. But in more exposed slopes or ridges, which do not suit the evergreen hardwoods, the deciduous hardwoods may be the climax community. Species of deciduous trees are numerous, including oaks, chestnuts,





birches, hornbeam, alders, catalpas, basswoods, maples, Firmiana simplex Wight, Liquidambar formosana Hance and Paulownia Fargesii Franch.

In deciduous hardwood forests lianas are abundant. Numerous species of Smilax, Actinidia, Clematic, Celastrus, Millettia, Mucuna, Pueraria, Lonicera, Rosa and Berchemia are widespread in the region. Many species of Loranthus have been found and some infect the tree so seriously that the tree becomes clad with the foliage of the parasites instead of its own.

In the bottomlands there are numerous deciduous trees, although such lowlands have entirely been devoted to rice culture. Alnus cremastogyne Burk is the most common tree in the western basin. It grows very rapidly and produces valuable fuelwood. Ficus lacor Ham. is common throughout the region along water courses. The extensive root system of this tree is highly valued in stabilizing river banks. But unfortunately the wood is nearly worthless, and is unsuitable for lumber and even for fuel. Pterocarya stenoptera DC. is abundant in the eastern basin. Willows and Paulownia fargesii, Pistacia chinensis Bunge, Firmiana simplex, Sophora japonica Linn. are commonly planted in the cities.

C. Cupressus funebris Forest. The cedar is of paramount importance in places where soils are alkaline. In many places the cedars are so severely pruned for fuel that only a tiny crown is left thus impeding their growth.

As mentioned above, in this region the soils are young and their nature is largely determined by the underlying rocks.





The mosaic distribution of different kinds of rocks results in mosaic arrangements of pine and cedar stands. Pine is usually on acidic and neutral soils, whereas cedar prefers neutral or alkaline soils.

Within the region tea, tung-oil trees and palm (Trachycarpus excelsa Wendl.) are commonly planted.

### The Southern Yangtze Mixed Forest

Location and Physiography. Except a mountainous portion on the borderland of Anhwei, Hupei and Honan, the region lies mostly south of the Yangtze River. The northern boundary is marked by the perimeter of the mountain-complex which disappears toward the margin of the plains. The western border is demarked by the foothills of the mountains which frame the eastern border of Kweichow. At the south, the foothills of this mountainous region is regarded as the dividing line of this region and that of the Southern Subtropical Monsoon Forest.

The topography of the region is fairly rugged with small alluvial plains along the rivers. This is hard and rocky land, largely underlain by granite, rhyoliteporphory, and other resistant formations. Only in sheltered basins are there softer formations, and these in turn give rise to rounded hills rather than to rugged mountains (Cressey, 1944).

All rivers at the northern side of the region are tributaries of the Yangtze River, whereas those on southern side run independently into the sea. Nevertheless both of them are rushing



streams winding through the rocky gorges. Except during periods of flood the rivers are so clean that the stony and rocky bed can be observed readily. This is in distinct contrast with the rivers in North China.

Within the region there are a number of isolated lofty mountains, which rise up to 1,700 m. These high mountains are scattered throughout the region like islands. Due to colder temperature and higher rainfall they support quite different types of forests. Two subregions are recognized based upon the natural occurrence of two endemic pines: Pinus liuchuensis var. hwangshanensis and P. parviflora var. Fenzeliana. The boundary for these two subregions can not be shown on the map because they comprise a group of discontinuous mountain summits and ranges. A contour line about 1,000 m. in altitude is regarded as their lower limit. The Kan River and its upper gap leading to southern Kwangtung is used as a dividing line for these two subregions.

Climate. The mean air temperature during January ranges from 2 to 10° C. It is not uncommon for the temperature to sink below -10° C. when the Siberian cold air mass sweeps down along the coast. The mean air temperature of July is about 30° C. The growing season ranges from 9 to 11 months.

Annual precipitation amounts to 1,000 to 2,000 mm. More than 50 per cent falls during late spring and early summer, resulting in a very humid period. This damp warm season is notoriously known as "the moldy season." Cressey (1934) describes it: "The humidity of the mould season is very high,





and the moisture condenses on all cool objects. Walls and ceilings drip with water, and perspiration fails to evaporate. The bindings of books become moldy, and shoes grow 'whiskers of fungus' overnight. Food spoils quickly and one's disposition is not of the best." Nevertheless this is the ideal season for vegetative growth of most trees, and especially suits the shoot growth of the bamboo (Phyllostachys edulis).

Following this wet season, a hot, dry period with clear, sunny sky, prevails over the whole region except on certain mountainous sections. The maximum temperature during this period ascends up to 40° C. Records above 45° C. have also been observed occasionally. Scattered thunderstorms are common.

Typhoons (corresponding to hurricanes) invade only the coast during summer. They are limited to the coast and do not penetrate far inland as do hurricanes in the eastern United States. Occasionally dry windy winters occur, and during these a number of evergreen trees suffer from desiccation. Ordinarily, there is a considerable amount of snow.

Soils. Due to the rough topography, the soils are mostly thin and stony. Soils of considerable depth are observed only in the foothills, valleys and gentle slopes. Alluvial plains of limited expanse exist along the rivers and small deltas occur at their mouths. Such lands are exclusively devoted to rice growing and, as a consequence, the soils are of the nature of rice paddy.

Within the region there are three important types of soils,



that is, red earths, podzolized red earths and brown or gray-brown podzolic soils. Except the scattered sand-dunes along the coast and patches of rendzenas in the southwestern border, most of the soils are acidic. The sand-dunes occur only in narrow and discontinuous strips (Hsi, 1946; Sung, 1946). The rendzenas are found due to special calcareous underlying rocks (Li, 1940). Yellow earths are extensively distributed in mountainous region especially toward the west.

Distribution of Pine and Bamboo. Except in mountains above 1,000 m. the pine in this region is exclusively Pinus Massoniana. It is very common, growing wild throughout the region and also is widely planted. Pine stands may be transitional in succession but they are quite stable on rocky ridges and dry slopes. On the mountains and hills near cities or villages, the stands are almost free from litter and undergrowth by virtue of constant clearance for fuel. As a result there is no chance for the establishment of hardwoods.

In southern Chekiang and coastal Fukien, Keteleeria Fortunei Carr. is often mixed with Pinus Massoniana and occasionally forms pure stands. Within the region, Cupressus funebris also sometimes occurs in small patches probably on more alkaline sites.

In connection with bamboos, there are numerous species but Phyllostachys edulis is of unique importance here. Although all stands observed are of artificial plantations, it is quite safe to assume that this region is also the native home of Phyllostachys edulis since this bamboo is so well suited to





the climatic conditions here.

In comparison with the northern plains the region has higher precipitation. The annual amount of precipitation in this region and in those of the Southern Subtropical Monsoon Forest and the Szechwan Basin Evergreen Forest are not very different. In this region, however, the winter receives about 15 to 20 per cent of the annual precipitation, whereas the spring receives 40 per cent or more. This is quite distinct from that of the other two regions where the winter and spring are drier. On the other hand, the winter in this region is much cooler than that of both the others.

Under such climatic conditions, this bamboo sends out its young shoots during spring and completes height growth of about 15 to 20 m. and diameter growth of 20 to 30 cm. within four to five weeks. The moderately humid winter and the rainy spring are necessary for such fantastically rapid growth. After completion of its dimensional growth, the hot summer materially promotes the hardening of the young shoot. As a consequence, the annual shoot is enabled to withstand the rather severe winter when the air temperature frequently drops far below the freezing point. Evidently this bamboo naturally does not invade the northern plains where the flat topography is more suitable for farming practice, and the precarious precipitation and the comparatively poorly drained soils are not suitable for the bamboo. The drier winter and spring in the southern and western adjacent regions are also unsuited to the fast growing spring





shoots of this species.

Generally the bamboo plantations are managed by intensive forest practices. Alternation of on and off years in the production of young shoots, is a well recognized occurrence. Only shoots of the on-year are kept as crop culms, whereas those of the off-year are cut for use as vegetables when they have just emerged from the ground.

The bamboo is harvested when it reaches the age of five years and thus leaves the stand with three-year and current culms.

#### Types of Forest.

A. Cunninghamia Plantations. Cunninghamia lanceolata is the most important commercial timber in China. It has been grown elsewhere in the region but always on moist and well drained soils. Planting of this tree alternately with farm crops and tree crops, such as tung-oil trees, tea-oil trees, and Manihot esculenta Crantz, is the general practice (Steward, 1934; Steward and Cheo, 1935; Pendleton, 1937; Chow & Ling, 1942; Ma, 1942; Su, 1943).

Clear cutting in small patches is very common. After cutting, the land is tilled or plowed for crops about three years. At the beginning of cultivation, seedlings or cuttings of Cunninghamia lanceolata and tree crops are planted among farm crops. After three years the tung-oil trees have become well established and start to bear fruit, then farm crops are stopped. Tung-oil trees give satisfactory harvest for about seven years. After that they begin to decline while Cunninghamia lanceolata



have already almost closed the stand. Consequently the farmer cuts the tung-oil trees and leaves the area entirely for Cunninghamia lanceolata. The rotation employed is usually short, ranging from 15 to 30 years.

Cunninghamia lanceolata not only produces fine timber, but also grows very rapidly. It attains a height of 15 m. and 20 cm. d.b.h. in 15 years. This occurs under exceptionally favorable conditions. But, in general, at the end of 30 years rotation trees have an average height about 14 m. and d.b.h. 20 cm. Furthermore, there are few epidemic diseases or insect pests. Since the tree can be easily propagated by cuttings, satisfactory strains can be maintained by vegetative regeneration.

Forests of Cryptomeria japonica D. Don which is closely related to Cunninghamia lanceolata are found in Chekiang. This conifer sometimes attains a size up to 2 m. d.b.h. Such big trees are commonly found growing around temples (Liang, 1931).

B. Deciduous Hardwood Forests. Although bamboo and pine are very extensive now, the deciduous hardwood seems to be the logical climax forest in most of the region, especially near the northern border. Hundreds of tree species have been recorded but undoubtedly oaks are the most important elements. Since oaks are the most tolerant trees here, they form the climax formation. The common deciduous species found in this region are: Quercus variabilis Bl., Q. aliena Bl., Q. acutissima Carr., Q. Fabri Hance, Liquidambar formosana Hance, Acer Burgerianum Miq., Sapindus Mukorossi Gaertn., Cedrela sinensis Juss., Firmiana simplex Wight, Platycarya strobilacea Sieb. &





Zucc., Castanea Henryi Rehd. & Wils., Albizzia kalkora Prain and Dalbergia hupeana Hance.

In lowlands, especially along rivers or lakes, Pterocarya stenoptera DC., Sapium sebiferum Roxb., Melia azedarach Linn. and many other deciduous trees are commonly found but they seldom form forests. They may form the edaphic climax within this oak climax region.

In bottomlands, Glyptostrobus pensilis K. Koch. and Pseudolarix amabilis Rehd. are found but there are no extensive stands (Metcalf, 1942). The forests of both conifers and hardwoods in bottomlands might have been abundant before invasion by humans. Now, everywhere there are only relict traces, since rice fields have encroached upon such areas completely.

C. Sclerophyllous Evergreen Forests. This type of forest should occupy more humid and warm localities where deciduous forests should be considered as successional communities. In the southern mountains where both moisture and temperature are more favorable, such type of forest predominates. Since the region has rather severe winter and rhythmic precipitation all evergreen broadleaved trees usually have sclerophyllous foliage. The common evergreens are: Castanopsis sclerophyllus Schott., C. Eyrei Tutch., C. hystrix DC., C. tibetana Hance, C. cuspidata Schott., C. Fordii Hance, C. Chuniana Hu, C. Carlesii Chun, Lithocarpus glabra Rehd., L. Henryi Rehd. & Wils. and species of Quercus, Phoebe, Schima, Machilus, Cinnamomum, Elaeocarpus, and Daphniphyllum. In most cases evergreen oaks and Castanopsis are so prominent that Fenzl (1930) called it the Quercus-



Castanetum.

Camphor trees are very commonly planted in villages. They sometimes attain quite large sizes but usually are infected by heart-rot. Tea, tung-oil tree, tea-oil tree and palm are other major tree crops.

Floristically and ecologically, this region is very similar to the eastern United States. But there is only one species of pine in the lowland of East China; whereas in the eastern United States there are a number of species of pines. Liriodendron chinense Sarg. has been found in eastern China but only in a few places. It is a small tree and not so common and picturesque as Liriodendron tulipifera Linn. in the eastern United States. There are several species of hickories in the eastern United States and they are widespread and fairly important constituents of hardwood associations, whereas in China there is only one species of Carya (C. cathayensis Sarg.) which is restricted to a few limited areas. Several species of beech grow in China but none is so ecologically important as American beech. Liquidambar formosana in eastern China and L. styraciflua Linn. in the eastern United States are probably of the same importance and abundance. Other trees as oaks, birches, alders, willows, and poplars have similar ecological position in both countries. But in China there are a great number of endemic arborescent genera such as Eucommia, Zelkova, Camptotheca, Aphananthe, Pteroceltis, Pterocarya, Platycarya, Ailanthus, Broussonetia and numerous tropical and subtropical elements. As a whole this region is richer floristically than the eastern





United States (Hu, 1926, 1929, 1935).

Subregion a. Southeastern Mountain Coniferous Forest.

This subregion is recognized by the occurrence of Pinus luchuen-  
sis var. hwanshanensis, which grows at an elevation above 1,000  
m. in the northeastern portion of the region.

The mean air temperature of January is slightly below 0° C.  
and that of July about 24° C. which is considerably lower than  
that of the surrounding lowland, where the maximum air tempera-  
ture of the same month occasionally rises up to 30° C. The  
growing season lasts about six to seven months.

The data from two stations show that the region as expected  
has higher precipitation than the lowland. The annual precipi-  
tation is about 2,000 mm. The rainfall is concentrated in  
spring and summer. In most places, this subregion is very  
cloudy and moist. The amount of snow is fairly high.

The subregion is extremely precipitous and rocky. Soils  
are thin and stony. Bare cliffs and outcrop-rocks are common.  
On account of cool temperature and high rainfall, the soils  
belong to the gray-brown podzolic type.

In this subregion, Pinus luchuensis var. hwangshanensis is  
the most common and important tree. It has been found every-  
where in southeastern China above the altitude of 1,000 m.  
(Tsong, 1936; Chien, 1927; Fan, 1935, 1937). The pine sometimes  
forms pure stands of considerable area in some protected valleys  
or on slopes. The stands have been cut either for lumber where  
transportation is not too difficult, or for the production of  
mushrooms and fuling (for medicine) (Poria cocos Wolf) (Fan,





1937) where the transportation of bulky lumber is not operable. The pine can become well established on rocky cliffs, towering summits, and precipitous ridges. Under such circumstances, it attains only a dwarf stature and often is strongly twisted and peculiarly branched. Such trees, of course, do not produce good lumber, but they aid in creating scenery that is attractive to visitors.

Other vegetation in this subregion are thickets and mountain meadows, because they can withstand the wind which sweeps these exposed regions.

Subregion b. Southern Mountain Mixed Evergreen Forest.

In this subregion Pinus parviflora var. Fenzeliana has been found (Cheng, 1938; Ma, 1941). There is little climatological data for this subregion. According to the only data from Hanshan, the climatic conditions here are nearly identical with those of the previous subregion.

The soils may be gray-brown podzolic soils in most of the region. But in flat localities podzolized yellow earths are likely to be developed.

Pinus parviflora var. Fenzeliana occurs in this area but does not form extensive pure stands. It often forms mixed evergreen forests with other conifers and hardwoods. Podocarpus spp. and Tsuga longibracteata Cheng are occasionally mixed in such forests. The climax formation of this subregion is the evergreen hardwoods which are composed of species of Castanopsis, Lithocarpus, Quercus, and members of the Lauraceae and Magnoliaceae families.



## The Southern Subtropical Monsoon Forest

Location and Physiography. This is the southernmost region in the mainland of China. The region lies mostly south of the Tropic of Cancer. The topography is rather flat with a few rolling hills.

The region is separated from the Southern Yangtze Mixed Forest by the perimeter of the mountain-complex in the north. This boundary coincides approximately with the isotherm of  $10^{\circ}$  C. of the mean air temperature of January. In the west, the boundary with the Yunnan Upland Monsoon Forest is set along the contour line of about 1,000 m. in altitude.

The eastern part of the region is drained by three large rivers, the Tunkiang, the Peikiang and the Sikiang, the last named being the largest. In the western part a number of rivers run from the north toward the south and eventually empty into the sea.

Climate. This is the warmest region on the mainland, the mean air temperature of January ranging from 10 to  $15^{\circ}$  C. When the strong Siberian cold air mass moves farther south, the temperature may occasionally sink slightly below zero. The mean air temperature of July is just about  $28^{\circ}$  C. which is about the average of other Chinese forest regions. The area as a whole is nearly frost free throughout the year.

The annual precipitation of the region is generally above 1,500 mm. and in some places up to 2,000 mm. Late spring and summer is the rainy season when about 70 per cent falls.





Autumn and winter are quite dry. Consequently the climatic type of the region is considered as the subtropical monsoon type. As in the monsoon forest, most trees stop their growth in winter because of dry weather not because of cold.

Along the coast the typhoons may occur during summer. Wind velocity up to 44 m. per second has been recorded. However, there are no authentic records of damage from windthrow or windbreak by typhoons.

Soils. With the exception of alluvial bottomlands along the rivers and deltas, the soil of the whole region is mostly red earths, which if covered by forests are more or less podzolized. Young podzolic red earths and gray-brown podzolic soils cover the hills and mountains extensively. The red earths sometimes have been so severely eroded that only vestigial remnants of the old A horizons can be found, but new A horizons are developing on the eroded soils of this group wherever vegetation has gained a foothold (Thorp, 1934).

Distribution of Pines and Bamboo. Pinus Massoniana grows sporadically in the eastern part of the region and Pinus insularis in the western part. According to Pendleton (1937), at lower elevations, particularly on the infertile uplands near the coast, Pinus Massoniana is extensively grown for the production of fuel and timber. The trees are selfseeded or small seedlings are planted in the very short grass on the plain or slopes, and are given practically no protection. This pine is reported by Fenzel (1930) as the most hardy pioneer



for reforestation of the deforested hills everywhere in south-eastern China.

In addition to the two species of pine mentioned above, the region is recognized by the natural occurrence of Sinocalamus latifolius. This bamboo attains a height up to 25 m. with a d.b.h. of about 20 cm. It grows in very large groups. The warm, moist climate makes such luxuriant growth possible. On the other hand, the rich foliage and the gigantic size of the bamboo are characteristic of the region. The bamboo sends out its young shoots during August when rainfall is abundant. It completes growth about November. Since the winter here is rather mild, the young tender culms can withstand the weather very well.

Types of Forest. The natural vegetation of this region has long been disturbed, especially in the east. It is difficult now to reconstruct a picture of the original vegetation or the possible climax communities. The present views regarding this succession are very controversial. Some authors consider this is a tropical rain forest while others assume it was savannah country.

So far as air temperature is concerned this is quite a warm country. The mean air temperature of January ranges from 10° to 15° C. As to rainfall, the annual precipitation exceeds 1,500 mm. in most parts of the region. The monthly precipitation during the dry months (from November to February) is below 6 cm. which is really too dry for a luxuriant rain forest, but not so low as can be sustained by savannahs.





According to Köppen's system (1931, this region belongs to his "Cwa" which means warm-winter-dry climate with mean temperature of the warmest month over  $22^{\circ}$  C. He set a demarcation between tropical and warm temperate on the bases of the average temperature of the coldest month  $18^{\circ}$  C. He considers that certain sensitive tropical plants would not thrive if the monthly temperatures are lower than  $18^{\circ}$  C.

Judging from the present relict vegetation and cultivated trees this region is however, much closer to tropical monsoon forests than to any warm temperate forests. The successful growing of banana, Bombax, coconuts and many other tropical trees proves that this is a region of subtropic climate. Based upon quite extensive observation, Pendleton (1937) came to the conclusion: "Coastal Kwangtung being distinctly sub-tropical, the methods of forestation suited to such conditions should be used, particularly as the attempts to apply temperate zone methods have at times resulted most unhappily."

The important types of forest in this region may be mentioned as follows:

A. Sclerophyllous Evergreen Forests. Since the winter is comparatively dry, especially in the lowlands, only a certain type of evergreen broadleaved trees can thrive in most of the region. They are either equipped with sclerophyllous foliages or their leaves are glaucous or hairy. Castanopsis fissa Rehd. & Wils., C. Fabri Hance, C. jucunda Hance, Lithocarpus spp. are all sclerophyllous; whereas species of Cinnamomum, Machilus, Schima and Phoebe are either aromatic or glaucous.





In such evergreen forest sites, plantations of Cunninghamia lanceolata are successful (Pendleton, 1937). However the regeneration is more difficult in this region because of lateness of the spring rains together with high temperatures during this same period (Fenzel, 1930).

B. Bottomland Jungles. In bottomlands, jungles consisting of bamboos, palms, and other swampy trees might once have dominated the area. In addition to Sinocalamus latifolius, banyan trees are still widely planted around farmsteads. Several tropical trees are planted successfully in the lowland, such as Canarium album Roesch., Cocos nucifera Linn., Euphoria longana Lam., Litchi chinensis Sonn. and Citrus spp. Caryota urens Linn. is commonly planted in the western region.

C. Deciduous Broadleaved Forest. This type of forest is the possible climax formation and might have occupied more extensive areas earlier. The important members of this formation are: Tamarindus indica Linn., Bombax malabaricum DC., Annona spp., Acacia confusa Merr., Albizia Lebbek Benth., and Bischofia javanica Bl. Leucaena glauca Benth. or "Ipil-ipil," a native of South America, was strongly recommended by Pendleton (1934) for reforestation of eroded places especially where coarse grasses are vigorous. He greatly praised its high fuel value, rapid growth and ability to improve soil fertility. Dalbergia sisso Roxb., introduced from India, has shown remarkable promise in early growth at Canton (Fenzel, 1930).



## The Yunnan Upland Monsoon Forest

Location and Physiography. The region includes the greater part of Yunnan, southeastern Sikang, southern Kweichow and western border of Kwangsi.

The boundary between this region and the region of the Southwestern Mountain Forest is set arbitrarily by a contour line of about 2,500 m. Owing to the deeply cut gorges, it is impossible to draw on the map an exact line based upon a definite altitude. It is also not feasible actually to set such a line. As a consequence, a group of towering mountains above 2,500 m. are included in this region, whereas a series of deep valleys which are far below 2,500 m. in the northwest of Yunnan are excluded. By such modification, a reasonably smooth line is obtained as shown on Map 1.

The region as a whole is very mountainous with few lakes of limited expanse. Most of the region lies between 1,500 to 2,500 m. of altitude.

Most of the rivers draining this region run southward, except the Kiangshakiang which is the upper tributary of the Yangtze River. Nevertheless, it has been maintained by geologists (Lee, 1939) that the Kiangshakiang probably flowed southward in former times instead of turning to the east as it now does.

Climate. The air temperature is mild throughout the year. The mean air temperature of January is usually above 9° C., and that of July rarely exceeds 20° C. In the southern part of the region especially in the lowlands the summer is warmer. However,





the mean temperature of such regions, during July, is just about 25° C., rarely slightly above. The growing season ranges from 10 to 12 months.

The annual precipitation is about 1,000 mm. The amount of rainfall is largely controlled by the altitude and the topography. Snow occurs very rarely except on high mountains.

The alternation of dry and wet seasons is clearly expressed by the occurrence of only 10 to 20 per cent of the total precipitation during the autumn and winter, and 80 to 90 during spring and summer. As the general level of the region is above 1,500 m., the humidity is low even during the rainy season. Clear and sunny skies always follow immediately after showers. On the other hand the winters are very dry and windy. This gives a distinct contrast to the cloudy and moist winter in the adjacent region of the Szechwan Basin Evergreen Forest. Otherwise both regions are similar in enjoying a mild climate.

Although winds prevail during the dry season, they are steady and moderate. Such mild winds do not cause any mechanical damage to the vegetation but they do aggravate the drought situation by intensifying the evaporation and transpiration. The cactus, which is believed to be an imported succulent from India, has shrunk considerably after the dry winter.

Owing to the dry, windy winter this is the region of the most serious fire hazard among all Chinese forest regions.

Soils. The important soil types in this region are red earths, purple earths and gray-brown soils. The red earths, which comprise the most important type, cover an extensive area



in the lowland. The distribution of red earths is below an altitude of 2,000 m. in the north (Ma, 1940) and 2,500 m. toward the south (Sung, 1940). The alternation of dry and wet seasons and steep slopes facilitates the formation of the red earths. All these soils are acidic. Rendzinas have been found in limited localities where the underlying rocks are soft limestones. Podzols are scattering on mountains of higher elevations. A very strongly acidic A<sub>2</sub> horizon has been reported to have a pH of 3.8 (Sung, 1940, 1946). Rice paddy soils occur along valleys or alluvial fans or lowlands bordering lakes.

Distribution of Pines. Pinus insularis is the most common and widely distributed tree in this region. It either forms pure stands or a mixed forest when associated with Keteleeria Davidiana Beiss. Either pure pine stands or mixed stands with Keteleeria Davidiana usually occupy the dry and exposed slopes which are the most common site conditions in this region. On moist and shaded slopes, however, Pinus Armandi predominates.

Without careful study, it is very difficult to determine whether the present widely distributed pine forests are transitional or climax in succession. The conspicuous alternation of dry and wet seasons may favor deciduous hardwoods as the possible climax as is sometimes the case in other countries. Liou (1941) considered that the present extensive range of pine is a result of constant disturbance by man. He also claimed that pines were transitional toward the climax of oak forest. But according to an extensive reconnaissance in Yunnan, by the writer, there are few deciduous hardwoods occupying considerable





areas, even in extremely thinly populated regions where disturbance should be slight.

Pinus insularis also grows naturally on higher mountains far south in Indo-China, Burma, and Siam. But it is restricted only to high elevations and does not form continuous and extensive forests. Such local stands may be considered as outposts of this region, though they belong to different nations.

For a long time the Yunnan pine has been described by botanists under two different names, that is, Pinus insularis Endlich and Pinus yunnanensis Franch. The specimens from Yunnan were usually recognized as P. yunnanensis or referred to as P. sinensis var. yunnanensis Shaw. But after a careful examination, the conclusion is reached that all specimens examined are referable to Pinus insularis Endl. (Wu, 1949).

#### Types of Forest.

A. The Sclerophyllous Evergreen Forest. Due to the alternation of dry and wet seasons, deciduous hardwood should be the climax formation. But in moist valleys or shaded slopes the climax formation is evergreen hardwood forest, since trees of evergreen hardwood are more tolerant than deciduous hardwood. The important species of evergreen hardwood are Lithocarpus Maireri Rehd., Castanopsis Delavayi Franch., C. concolor Rehd. & Wils., Quercus Schottkyana Rehd. & Wils., Q. Delavayi Franch., and species of Machilus, Phoebe, and Schima. They are all semi-xerophytic and thus can avoid desiccation during the dry weather. On higher elevations Quercus semicarpifolia Sm. forms quite extensive pure stands.





B. Deciduous Hardwoods. The deciduous trees are usually mixed with pine forest and exist as codominant (Yu, 1934). Quercus variabilis Bl., and Q. dilatata Lindl. are the most common deciduous trees. Alnus nepalensis D. Don. and Betula spp. occur on exposed slopes. In lowlands, especially along water courses, Populus yunnanensis Dode, Pterocarya stenoptera DC. and Alnus nepalensis are common.

C. Other Types of Forests. Stands of Libocedrus, Fokienia, Taiwania, Cupressus Duclouxiana Hickel. are also found. The last named species is also widely planted around farmsteads.

On more dry and exposed slopes or in rain shadows, scrubby woodlands frequently occur. Several drought resistant species as Phyllanthus embelica Linn., Pistacia weinmannifolia Poiss., Terminalia Franchetii Gagn., Englehardtia Colebrookiana Lindl. and Woodfordia floribunda Salisb. form park-like woodlands intermingled with coarse grasses (Handel-Mazzetti, 1921).

### The Hainan Subtropical Forest

Location and Physiography. The island of Hainan lies south of latitude 20° N. The island is recognized as a separate region because of its geographical isolation from the mainland. But for the sake of convenience all islands south of Hainan are also included in this region. On account of strong salt spray and the thin soils, which are mostly of coral origin, forests are poorly developed on such small islands.

Although several botanical and zoological explorations have



been conducted in Haidna, information regarding natural environmental conditions is meager. In general, the central and the southern parts of the island are mountainous. But the altitude of this region is rather low. The highest is the group of pinnacles of Chichihling, with the altitude not quite 1,900 m. (Hayasaka, 1948). This region is quite dissected and the slopes are generally unexpectedly steep. On the northern part of the island, there is a dissected and eroded plain. It has been estimated that about 95 per cent of the total area of the island is below 700 m. altitude (Liang & Chu, 1948).

Most of the rivers in the island have their headwaters in the central-northern mountainous region. They run centrifugally toward the coast and empty independently into the ocean. Only a few rivers are longer than a hundred kilometers. The Nantuho, the Wanchienho, the Changkiang and the Shinchangkiang are the most important ones (Ting et al, 1935).

Climate. The climatological data for the whole island, are inadequate. Except on high mountains, the island has a tropical aspect. The mean air temperature of January is about 17 to 18° C. and that of July is about 28 to 29° C. The annual range of air temperature is about 10° C., which is the lowest among the Chinese forest regions.

The annual precipitation ranges from 1,200 to 1,500 mm. At higher altitudes, the amount may be greater. The distribution of precipitation is rhythmical. January, with a rainfall of about 14 to 25 mm., is the driest month.

The region has been described by climatologists as having





a tropical savannah climate (Lu, 1944; Borchert, 1947). This may be true of the lowlands. In the southern mountainous region the precipitation is high throughout the year (Hayasaka, 1948) and the climate is expected to be of monsoon forest type. This has been confirmed by the vegetation observed (Tso, 1934; Fenzel, 1933).

Soils. The major soil type on the island is the red earths. But in the mountainous areas, there are yellow earths. Due to the high temperature and high precipitation the chemical weathering proceeds rapidly. As a consequence, the surface soil in rainy mountainous regions is very deep (Hayasaka, 1948).

Distribution of Pines. On the island three species of pine have been collected. Pinus Massoniana and P. Merkusii grow in lowlands, whereas P. parviflora var. Fenzeliana occurs in the evergreen hardwoods.

#### Types of Forest.

A. Lowland Savannah Forests. The major part of the lowlands has been cultivated or disturbed. Otherwise it would be mostly covered by coarse grassland or chaparral vegetation with fringing forests along the rivers. However, Pendleton (1934) considered this type of vegetation as artificial savannah. Species of Caesalpinia, Randia, Phyllanthus, Glochidion, Capparis, Cassia, Mallotus, Uvaria, Erythrina, and Ficus are important woody elements. They are all drought resistant and some are spiny. Along rivers, the trees form fringing forest. The common tree species in such forests are species of Litho-



carpus, Eugenia, Ficus and Quercus cornea Lour., Q. litseifolia Hance, Dalbergia Hancei Benth., Melia azedarach Linn., Manglietia Fordiana Oliv., Ormosa Fordiana Oliv. and Crataeva lonphosperma Kurz. (Tso, 1934).

B. Evergreen Hardwood Forests. On the higher elevations, although destructive logging proceeds rapidly, there are still evergreen broadleaved forests. Species of Eugenia, Engelhardtia, Castanopsis, Quercus, Gironniera, Ficus, Magnolia, Cinnamomum, Beilschmiedia, Michelia, Fitsistigma, Phoebe, Cryptocarya, Eustigma, Altingia, Machilus, Elaeocarpus, Garcinia, Alniphyllum, and Artocarpus are dominant elements. The undergrowth is also abundant. Epiphytes, consisting of orchids and ferns, occur on the bark.

### The Taiwan Forest

Location and Physiography. The island of Taiwan is located between longitude 122° 6' 15" E. to 120° 2' 16" and latitude 21° 45' 25" to 25° 37' 53" (Ho, Cheng & Cheng, 1946). It is separated from the mainland by the Taiwan Strait, having a width of about 150 kilometers. As a forest region the Panhu Islands (or the Pescadores Islands) should also be included.

The configuration of the island is that of a tilted fault block, sloping to the west from a range of high mountains along the eastern axis. The highest peak in the island is the Yu Shan (formerly known as Shinkaoshan or Mt. Morrison), 3,950 m. In general the island has a mountainous region on the east and





fertile coastal plains bordering the western shore. The area and percentage of the whole island at different elevations have been estimated as follows (Liang & Chu, 1948):

| <u>Altitude (m.)</u> | <u>Area (hectare)</u> | <u>Percentage of the Total Area</u> |
|----------------------|-----------------------|-------------------------------------|
| below 700            | 2,015,355             | 56                                  |
| 700-1,200            | 614,820               | 17                                  |
| 1,200-1,800          | 428,502               | 12                                  |
| 1,800-2,400          | 321,522               | 9                                   |
| 2,400-3,000          | 171,409               | 5                                   |
| above 3,000          | 44,712                | 1                                   |

With such a wide range in altitude, the island involves forests ranging from tropical to boreal types. Although more than half of the area lies below 700 m., the lowland is mostly devoted to agriculture. The forests in the different altitudinal belts are nearly of equal importance except those above 3,000 m.

There are numerous rivers which run from the central mountainous region and empty independently into the ocean on all sides of the island. The rivers are all short and often swift. Only six rivers in the island are longer than one hundred kilometers. They are the Shushui (165 km.), the Hsiatanshui (156 km.), the Tanshui (130 km.), the Tatuchi (112 km.), the Takiachi (118 km.) and the Tanchi (100 km.) (Ho et al, 1946).

Climate. By virtue of the wide range in elevation, the island shows a great variation in climate. Both temperature and precipitation at high elevations are of course different





from those in the lowlands, as shown by the available climatological records.

The air temperature in the lowlands decreases from the south toward the north. The southernmost part has a typical tropical-monsoon climate. The mean air temperature of February (the coldest month) at Hentseng is  $20.3^{\circ}$  C.; whereas that of July is  $27.5^{\circ}$  C. The annual range in mean monthly temperature is only  $7.2^{\circ}$  C. In the northern part of the island, the mean air temperature of February is  $13.4^{\circ}$  C. whereas that of July is  $28.1^{\circ}$  C., making an annual range  $14.7^{\circ}$  C. The growing season in the lowlands extends almost throughout the year (Sung, 1946).

Since the mountain trends in the island are mainly oriented in a north and south alignment, the climate changes from north to south so gradually that no sharp demarcation can be perceived.

Precipitation generally decreases toward the west, because of the orientation of the mountain ranges just mentioned. As the mountains keep out the moist wind from the open sea to the east, the country on the western side of the island is consequently considerably drier than that on the eastern side.

The annual precipitation ranges from 1,000 mm. along the western coast to 2,500 mm. on the eastern coast. Around Huashao-liao and Chinshuiyin high precipitation of more than 4,000 mm. has been recorded. In the central mountain region, the annual precipitation is mostly over 3,000 mm. (Chen, 1948).

The distribution of precipitation in the south is entirely different from that in the north. The southern part has its



precipitation concentrated in summer. In Hentseng for example 88 per cent of the total precipitation falls during April to September. On the other hand, the northern part has winter rainfall predominately. In Keelung 56 per cent of the annual precipitation falls during the period from October to March.

Speaking generally, the island has quite abundant precipitation. Moreover, the number of raining days is also high, ranging from 150 to 180. With the exception of the western coast, the island is fairly cloudy and moist. The average relative humidity ranges from 75 to 80 per cent.

The Panghu Islands have less precipitation. The annual precipitation in Makung is 988 mm. However, these islands have higher relative humidities varying from 77.16 (October) to 86.4 (June).

Winds from air currents over the straits sweeps along the western coast throughout the year. But it is in the late summer and early autumn that destructive typhoons invade the island. Maximum speed up to 40 m. per second has been recorded. Wind-throw and windbreak may be serious along the coast (Nun, 1948). On September 25 and 26, 1946, a destructive typhoon broke trees up to 20 cm. d.b.h. Typhoons also indirectly cause floods in the island (Chen, 1948).

Soils. There is little information about soils of these islands. Most of the forest reports do not mention soils at all. Others list the topic of soil but do not give any concrete descriptions.

On account of the wide range of elevation as mentioned





above, there are many different groups of soils. According to Ru and Hua (1947), the major groups of soils, as found in Taichung District, are red earths, yellow earths, gray-brown soils and podzols. The red earths are distributed at lower elevations (100 to 400 m.) and are mostly devoted to agriculture. The yellow earths and the gray-brown soils are located at higher altitude (400 to 2,500 m.) and are developed under mixed forests. The podzols occupy still higher elevations, and are developed under coniferous forest. On higher mountains, there are mountain meadow soils. In addition, there are several minor intrazonal and azonal soil groups which are not important to forest.

Distribution of Pines. Four species of pine have been recorded. They are Pinus luchuensis, P. Massoniana, P. Armandi var. morrisonicola and P. parviflora var. morrisonicola. However, all these species do not form extensive pine forest on the island. As in the case of Hainan Island, this region is recognized chiefly on the basis of its geographical isolation.

### Types of Forest.

A. Mangrove-like Forests. Along the coast near Kaoyun (Takao) and Keelung, mangrove-like forests have been observed (Wilson, 1920; Kanehira, 1936). Owing to the scarcity of muddy swamps on the island, however, such forests are very poorly represented. The important aborescent species of mangrove are: Rhizophora mucronata Lam., Lumnitzera racemosa Milld., Avicennia marina Vierh., A. officinalis Linn., Kandelia candel Merr., K. Rheedii Wight., Ceriops Tagal C. B. Rob. and Bruguiera



conjugata Merr.

B. Coastal Woodlands. The greater part of the lowlands has been devoted to agriculture. But where not cleared for cultivation, the foothills are covered with a dense jungle growth of coarse grass, bamboos, miscellaneous shrubs and trees of no great value (Wilson, 1920). The common ligneous species are: Phoenix Hanceana Naud., Pittosporum formosanum Hay., Scaevola Koenigii Vahl., Excoecaria Agallocha Linn., Hibiscus tiliaceus Linn., Pongamia glabra Vent., Caesalpinia bonducella Bl., Clerodendron inerme Gaertn., Ipomoea biloba Forsk., Canavalia obtusifolia DC., Myoporum bontionides A. Gray, Hibiscus mutabilis Linn., Kleinhovia hospita Linn., Cerbera odolham Gaertn., Rauwolfia chinensis Hemsl., Acacia Farnesiana Willd., A. confusa Merr., and species of Elaeagnus. Vitex negundo Linn. is widely distributed and very abundant in the lowlands, whereas Vitex ovata Thunb. predominates in the tidal land.

Scattered among farmsteads or on bare slopes, a number of deciduous trees are frequently observed. The most common deciduous trees are Alnus formosana Makino, Liquidambar formosana, Bischofia javanica, Fraxinus insularis Hemsl. and Quercus variabilis.

C. Evergreen Hardwood Forests. These forests exist from lowland up to an altitude of 2,000 m. in nature of climax formation. They are the most luxuriant vegetation and are very rich in floristic components. The predominating species are members of Lauraceae and Fagaceae. The following are important species:





Castanopsis Junghuhnii Hay., C. taiwaniana Hay., C. formosana, C. Kawakamii Hay., Lithocarpus Kawakamii Hay., L. castanopsisi-folia Hay., L. amygdalifolia Hay., L. Knoiishii Hay., and a number of evergreen oaks. It may be considered as the Castanopsis-Lithocarpus climax.

In these forests certain conifers are found, such as Keteleeria Davidiana Beiss., Libocedrus formosana Florin, Pseudotsuga Wilsonii Hay., Podocarpus Nakaii Pilger, Pinus Massoniana, and P. luchuensis. But none of these conifers forms extensive pure stands or are represented in mixed stands as dominants. They should be considered as a successional community.

With reference to undergrowth in these evergreen forests, it varies from place to place according to the amount of rainfall and disturbance by man. On the eastern coast where precipitation is generally higher and disturbance slight because of its inaccessibility, the undergrowth is luxuriant. Species of ferns and bananas really accentuate the profusion of the undergrowth.

Epiphytes are also very abundant in some localities. The striking lianas as Calamus Margaritae Hance, Mucuna feruginea Matsum., Entada phaseoloides Merr., Ecdysuathera utilis Hay., E. rosea Hook. & Arn. and Ficus Awkeotsang Hay. give the forest an enormously luxuriant appearance. A number of epiphytic orchids on trunks add to the luxuriance of these magnificent evergreen forests.

The evergreen forests with rich undergrowth and epiphytes, as mentioned above, give a splendid physiognomy. They have consequently been described as rain forests (Kanehira, 1936,





Wilson, 1920).

In places of less rainfall, the undergrowth is much less abundant. Sometimes this forest forms open stands with several deciduous hardwoods such as Quercus variabilis and Liquidambar formosana in association.

D. Evergreen Coniferous Forests. This type of forest exists mostly within the belt of 2,000 to 3,300 m. Economically, this is the most important forest region on the island. Since they produce large amounts of timber with uniformly high quality, these forests have been profitably exploited by large scale operations.

The most important species here are Chamaecyparis formosensis Matsum., C. obtusa Sieb. & Zucc. and Taiwania cryptomerioides Hay. Wilson (1920) highly praised these forests as the finest forests of eastern Asia. He claimed that Chamaecyparis formosensis is the largest and Taiwania cryptomerioides the tallest coniferous trees known outside of California. On a higher elevation, Picea morrisonicola Hay. and Tsuga chinensis Pritz gradually become dominants. Still higher (above 3,000 m.) Abies Kawakamii Ito predominates.

In the evergreen coniferous forests, several deciduous trees are present as subordinate associates. They are Trochodendron aralioides Sieb. & Zucc., Alnus formosana, Ulmus Uyematsui Hay. and species of Acer.

E. Subalpine Woodlands. Above 3,300 m. the air temperature becomes precarious for high forests. But as a whole, since the



island lies astride the Tropic of Cancer, and no mountain rises above 4,000 m., there is no place that really extends above timber line. Nevertheless on certain summits, there are no forests.

On such high mountains Juniperus squamata Lam. forms dwarf woodland with species of Rhododendron, Spiraea, Rosa, Berberis and Lonicera. Such formations are very similar to those on the high mountains of western China.

### The Loess Upland Steppe and Woodland

Location and Physiography. This region is widely known as the Loess Upland, which is nearly equally covered by the rolling basins and the towering mountains. On the east, the region is bounded by the perimeter of the North China Plain. On the south, it is limited by the northern foothills of the Tsingling Ranges. On the west it is bounded by a contour line of 2,500 m. altitude. On the north, for the sake of convenience and distinction, the Great Wall may be regarded as the boundary but excluding the Kansu Corridor.

Within the region two subdivisions are recognized: the mountain woodlands and the basin steppes. The dividing line for these two subdivisions is set along a contour line of 700 m. in the east and gradually increases to 2,000 m. toward the west.

The kind of original vegetation in this region is quite controversial. Based upon the amount and distribution of the





prevailing rainfall and nature of the soils, the basins might have once been grassland with fringing forests limited to the margins of water courses. The mountains, especially toward the east, where the precipitation is higher and the soils are thin and sandy, might have been covered with forests. Relict forests still exist in less accessible places but they are vanishing rapidly from destructive exploitation. Toward the west, however, the precipitation becomes more precarious. As a consequence, even on high mountains forests may occupy only moist spots or northern slopes, which James (1935) calls Ubac slopes; whereas most of southern slopes are believed to have been covered by steppe or scrub-woodlands.

The region was formed by deposits of loess which formed an undulating sea. Scattered throughout this loess sea, there are numerous towering mountains. After a long period of serious erosion, as a result of improper land utilization, this homogenous surface has been deeply dissected by gorges and gullies.

Two rivers: the Weiho and the Chinho drain most of the western portion of the region. They empty into Yellow River at the juncture of Shensi and Honan provinces. In the eastern part, the Fengho is the main drainage. These rivers are all notorious for their enormous silt content and exceedingly great fluctuation in volume of flowing water. The silt content of the Weiho has been reported to amount to 45 per cent (Konter, 1935), and that of the Chinho 50 per cent (Ho, 1937). The fluctuation of the flowing water<sup>of</sup> the Weiho, ranges from 6,000



to 30 cubic meters per second (Li, 1934). The solid content of the Fenho flood is reported as high as 30 per cent (Smith, 1926).

Climate. The climate of this region is of the continental type. The mean temperature for January varies from  $-5$  to  $-15^{\circ}$  C. An extreme low temperature of below  $-25^{\circ}$  C. has been recorded frequently. On the other hand, the summer is fairly warm. The mean temperature of July ranges from  $22$  to  $28^{\circ}$  C. Since the relative humidity is rather low, cool summer nights are common.

The growing season is about six to seven months long. Late frosts during April are common and are notoriously known as "black frost" because the young shoots killed by frost turn black overnight.

The annual precipitation in the lowlands ranges from 500 to 300 mm. The rainfall is not only low in average amount but also uncertain. Although a high percentage of the total rainfall occurs during the growing season, it is usually in a few torrents and is mostly lost by surface run-off. On the higher mountains not only may the annual precipitation exceed 500 mm., but the lower temperature may also reduce the evaporation rate, and thus increases the effectiveness of the rain.

In the western portion, the Wei Basin, the föen (corresponding to chinook in North America) affects the air temperature and humidity. It has been observed in Chin-Yuang that the air temperature may increase from  $12.6^{\circ}$  C. to  $34.5^{\circ}$  C. in eight hours (Cheng, 1942). As a result the relative humidity





is much reduced. This part of the region, on account of the föen, usually has higher air temperatures except during winter when the cold air mass from the north predominates.

Soils. Soils of the Loess Upland are usually calcareous. Strictly speaking, loess is the soil material, which occurs over wide areas and has an average depth of 30 to 60 m. sometimes even up to 100 m. Where it occurs in large bodies and has been eroded, it stands in vertical cliffs and exhibits a strongly developed columnar structure.

The loess soils (löss-böden) (Tschau et al, 1935) or immature light and very light chestnut-colored soils of loessial origin (Thorp and Hou, 1935) occupy a very large area in the Loess Upland. Due to the constant fresh dust-deposition and slight leaching, the soils are immature in development. The profile of the loess soils often consists of only A and C horizons, the B horizon being undeveloped (Tschau et al, 1935).

Westward from the Wei Basin the percentage of light chestnut soils rapidly decreases and the percentage of dark chestnut increases. Immature chernozems are scattered widely at higher elevations. While they are still immature they show a much greater degree of profile development than the immature chestnut and light chestnut earths (Thorp and Hou, 1935). Along the alluvial plains or fans there are fresh deposits of saline or non-saline calcareous alluvium.

Distribution of Pines. Two species of pines have been found in this region: Pinus tabulaeformis and its varieties





and P. Bungeana. Pinus tabulaeformis is much more widespread and can become established even on drier sites. According to Yang (1937), forests of Pinus tabulaeformis are rather a transitional stage in the course of successional development, as indicated by the absence of young pine seedlings in the stand. The pine stands will eventually be succeeded by more tolerant deciduous hardwoods such as oaks. As to Pinus Bungeana which has very limited distribution, it has been found to be dominant in protected woodlots around temples. Smith (1926) found that forests of this pine are very dense and with plenty of young trees of all sizes, though the soil is more or less stony and dry.

#### Types of Forest or Other Plant Communities.

A. Lowland Scrubby Vegetation with Fringing Forests along Water Courses and Woodlots around Farmsteads. Judging from the precipitation and the deep loamy soils, the lowland is unable to support forest. The basins are now under intensive cultivation. The wild vegetation that remains is of a xerophytic type. Because of overgrazing, the region is poor in grasses which might once have dominated the area. The abandoned areas which are heavily grazed are mostly covered by species of Compositae, such as Artemisia Sieversiana Ehrh., A. Mattfeldii Pamp., A. scorum var. latiloba Ledeb., Chrysanthemum nematolobum Hand.-Mazz., Aster altaicus Wild., Lactuca chinensis Makino and some legumes such as Astragalus scaberrimus Bunge, and A. taitaricus Franch. Where the soil is highly calcareous, species of Chenopodiaceae become important. Where wide fluctuations in



soil moisture occur, a number of sedges, grasses and Iris ensata Thunb. predominate. There are also a number of spiny shrubs commonly found in this area. They are species of Berberis, Lycium, Caragana and Sophora viciifolia Hance, Hololachne sangaria Ehrh., Zyzyphus spinosa Hu. On very dry slopes, Nitraria Schoberi Linn., N. Roborowskii Komarov, Peganum harmala Linn., P. nigellastrum Bunge, Statice aurea Linn., S. bicolor Bunge, and species of Zygophyllum form open communities (Walker, 1941; Pei, 1948).

Trees in the basins grow only along water courses. But they are also commonly planted around farmsteads. Salix Matsudana Koidz., Ulmus pumila Linn., Populus Simonii Carr., P. pyramidalis Salish., P. tremula var. Davidiana, Sophora japonica Linn., Ailanthus altissima Swingle and Thuja orientalis Linn. are most commonly planted.

Black locust (Robinia pseudoacacia L.) has been introduced and seems very promising except toward the north. Salix Matsudana is widely planted along river banks. It is propagated by means of cuttings and is managed in nature by the pollarding coppice method. A rotation of about five years is generally practiced.

In extremely dry places almost no other tree can thrive except Elaeagnus angustifolia Linn. which attains considerable size, 15 m. height, 1 m. d.b.h. (Walker, 1941), far exceeding that of any other species of the family in the south. In salt marshes or along swamps, Hipophae rhamnoides Linn. var. procera Rehd. and Myricaria germanica Desv. are common.





B. Mountain Forests. On higher mountains, especially in inaccessible areas, there are quite extensive forest tracts (Lin, 1926, Lowdermilk, 1926; Smith, 1926; Tang, 1931; Ren, 1934; Takahasi, 1936; Young, 1937; Chen, 1944). The density of these forests depends largely upon the amount of local precipitation. In general, forests become less abundant from east to west, as well as from south to north. The altitude favorable for the general incidence of such deciduous forests increases from 700 m. (Yang, 1937) near the eastern border to 2,000 m. (Chu, 1946) toward the west. This picture, however, has been modified by long-continued disturbance, and everywhere in the region, the forests are restricted to certain limited areas.

The common species of deciduous forests observed are Quercus liaotungensis, Q. mongolica, Q. aliena, Q. dentata, Betula mandshurica var. szechuenica Rehd., B. albo-sinensis Burk, B. albo-sinensis var. septrionalis Schneid., B. Delavayi Franch., Populus alba Linn., P. tremula Linn. var. Davidiana Schneid., P. cathayana Rehd., P. Simonii Carr., Thuja orientalis and species of Acer, Tilia, Fraxinus, and Ostryopsis.

As a whole, oaks always predominate at lower elevations, whereas birches become important at higher altitudes.

Still higher (above 2,500 m.), there are spruce forests. Two species of spruce have been found: Picea asperata and P. Wilsonii. In addition, larch (Larix Gmelini var. Principis-Rupprechtii Pilger) is scattered at elevations of about 3,000 m. or higher.



## DESCRIPTION OF NON-FORESTED AREAS

### The Northeastern Plain

This plain is also known as the Manchurian Plain. It is almost entirely surrounded on all sides by mountains. Wheat and soybeans, kaoliang, millet and corn are the main crops.

The mean air temperature of January ranges from about  $-5^{\circ}$  to  $-20^{\circ}$  C.; and that of July about  $20$  to  $25^{\circ}$  C. An extreme maximum of  $40^{\circ}$  C. in July and an extreme minimum of  $-45^{\circ}$  C. in January have been recorded. The growing season is about five to six months long.

Precipitation is seasonal, with light winter snowfall, a dry spring and fall, and concentrated rain in June, July and August. The amount of precipitation decreases from 700 mm. in the east to 350 mm. in the west. Along the coast of the Liaotung Peninsula it reaches 1,000 mm.

The topography of the erosional plain is rolling. In order to maintain a sustained land utilization of this newly developed area, a certain amount of farm woodlots should be kept. The common trees in the plain are: Pinus tabulaeformis, Pinus



koraiensis, Ulmus pumila, and Quercus liaotungensis.

### The Great Northern Plain

This is an enormous alluvial fan and delta, built into a crescentic bay once occupied by the Yellow Sea. The land is amazingly flat with less than 50 m. variation in elevation. The rivers of the plain flow on ridges rather than in the valley as a result of tremendous silting and progressive raising of the dikes.

Throughout the plain bordering the coast, the climate is rigorous. The mean air temperature of January varies from zero to  $-5^{\circ}$  C., and that of July from 25 to  $30^{\circ}$  C. The extreme maximum of  $47.8^{\circ}$  C. in July and the extreme minimum of  $-24.5^{\circ}$  C. in January have been recorded. The growing season lasts about six to seven months.

The annual precipitation ranges from 400 to 500 mm. The annual precipitation is not only precarious but also notoriously unreliable. In Peiping the extreme minimum annual precipitation was recorded as 168.5 mm. in 1891, and the maximum 1084.4 mm. in 1895. During winter, dust storms are common and severe.

Judging from the small amount of rainfall which is concentrated in summer, and the deep loamy soils, it is believed that the plain was formerly dominated by steppes with scattered trees in more moist spots or along rivers.

The North China Plain is now entirely under cultivation. Wheat and kaoliang are the main crops. The trees now commonly





growing naturally or planted in this plain are: Ulmus pumila, Salix Matsudana, Gleditsia sinensis Lam., Ailanthus altissima, Sophora japonica, Paulownia tomentosa, Catalpa Bungei and Thuja orientalis. In order to prevent dust storms, shelterbelt planting is urgently needed. The above trees are suitable for this purpose.

### The Yangtze River Lacustrine Plain

This plain is separated from the Northern Plain by the boundary which divides the calcareous soils on the north from the non-calcareous alluvial soil on the south. The plain is also the boundary which separates the wheat region on the north from the rice region in the south.

Within the plain there are numerous lakes and a network of canals.

The mean air temperature of January is about 0 to 5° C. and that of July is uniformly about 30° C. The annual precipitation is about 1,000 mm., which is mostly concentrated in the period from April to September.

As a result of long intensive cultivation, there is no trace of the original vegetation. It is quite possible that the region was once dominated by bottomland hardwood forests. Rice is the most important crop here. The common trees found are: Celtis sinensis Pers., Ulmus parvifolia Jacq., Liquidambar formosana, Quercus variabilis, Q. acutissima, Q. Chenii Nakai, Pterocarya stenoptera, Aphananthe asperata Planch., Zelkova



sinica Schneid., Broussonetia papyrifera L'Her., Morus alba Linn., Albizzia kalkora, Catalpa ovata and a number of willows.

### The Tibetan Alpine Tundra

The average altitude of the Tibetan Plateau usually exceeds 4,000 m. A number of summits tower above 5,000 m. Except the borderland, the area as a whole is too cold and usually also too dry for conspicuous vegetation, including forests and steppes. The southern border of the plateau, where boreal forests exist, is included under the Southwestern Mountain Forest.

The only available climatological data are obtained from Lhasa, the capital of Tibet. The mean air temperature of January is 0° C. and that of July is 16.7° C. The growing season is about four months long. The annual precipitation is surprisingly high, up to 2,703 mm. However, this can not be used to represent the region as a whole. Of the total amount of rainfall, 99 per cent falls during the period of May to September. This is based upon two years record and so needs further confirmation. Moreover, Lhasa, where the climatological data cited above were taken, lies at an elevation of 3,600 m. which is located far below the average altitude of the plateau. In addition, the city is located eccentrically toward the southern border. Actually, there are no extensive forests on the plateau proper. The only vegetation consists of perennials which often build cushion-like sods. A few shrubs as Myricaria





bracteata Royle and species of Berberis grow along rivers. In depressions and swamps, sedges become dominants.

### The Great Northwestern Grassland

North of the Loess Upland, west of the Great Khingan Mountains, and north of the Tibetan Plateau, there is an enormous area having a semi-arid and arid climate. In this semi-arid region, grasslands predominate. However, the dividing line between arid and semi-arid has not been well recognized. The dotted line used in Map I is drawn according to the maps prepared by Tung (1943), Chen (1944), Lu (1946) and Borchet (1947) and is modified in accordance with the atlas by Ting et al (1936).

The climatic conditions here are rigorous. The mean air temperature of January ranges from  $-10$  to  $-26^{\circ}$  C. and that of July about  $20$  to  $32^{\circ}$  C. The extreme maximum rises to  $40^{\circ}$  C.; whereas the extreme minimum sinks to  $-40^{\circ}$  C. The growing season lasts about four to six months. The annual precipitation is about 150 to 350 mm. which is largely concentrated in summer.

The important elements of the grassland are: Stipa splendens Trin. which sometimes forms extensive tall grasslands, S. capillata Linn., S. breviflora Griseb., Festuca ovina Linn., Poa attenuata Trin. and Elymus dasystachys Trin. (Keng, 1945).

Within this grassland, there are two kinds of woodlands in certain particular localities. They are fringing woodlands



along water courses and subalpine woodlands on mountains above certain elevations.

A. Fringing Woodlands (or woodlands in oases). Several species have been found forming open woodlands along the rivers or near oases. Populus euphratica Oliv. is the most important tree in the western part and Ulmus pumila is more common toward the east. Other trees as Populus pyramidalis, Elaeagnus angustifolia and a few species of willow and tamarix are also found.

B. Subalpine Woodlands. Above the grasslands there is usually a belt of forest in mountainous regions. In the Great Northwest, however, such localities are few and limited to the borderland only. On account of the greater precipitation at certain altitudes, a belt of forest occurs if air temperature is not too low. The general altitudes of the forest belt in this region are controversial. Liou (1934) noted the belt lies between 1,400 to 2,800 m. Machatschak (1912) reported that the belt of 1,300 to 2,500 m. was the forest region where Picea Schrenkiana Fisch. & Mey., P. obovata Ledeb., Abies siberica Ledeb. and Larix siberica Ledeb. predominate. Sewerzow (1897) based upon his extensive observations stated that: "The zone of winter snow clouds occur in the Tienshan, at an altitude of 2,500 to 3,000 m.; this is at the same time the zone of silver fir forests which are wanting at lower altitudes on account of the dryness. The higher regions receive but little winter snow; on the other hand, they receive richer supplies of rain from the





higher summer clouds, and this favors the growth and the presence of good pasture in these altitudinal zones." (Schimper, 1903). Specimens of Pinus cembra var. siberica Loud. have been collected from Mt. Altai.

Cheng (1944) noted on the southern slopes of the Tianshan, that the forest belt lies within the altitude of 3,000 to 3,500 m. Such forest belt, however, does not exist in the eastern part of Kucha. On the northern slopes of the Kunlun Mountains, the forest belt is located at the altitude of 3,000 to 3,650 m. He also mentioned that there is no forest on the Altyn Tagh Mountains.

According to Chang (1949), both on the southern slope of the Tien Shan and on the northern slope of the Kunlun, no forest of any considerable size occurs, and true pastures, also, are lacking.

There is no adequate information regarding the forest situation in this region. As a whole the forest area here is very restricted. The actual altitude of forest belt must be different in different mountains depending upon their location and topography. The belt is not only very narrow but also not always present.

Although the total area of such subalpine boreal forests is negligible in proportion to the vast expanse of the Great Northwest, these forests are of paramount importance in connection with the water protection and supplying the necessary timber in this nearly treeless region. Therefore rational management to utilize the wood wisely as well as to maintain





the forest is urgently needed.

### The Sinkiang-Mongol Desert

Inside the grasslands there are a number of vast desert basins, which occupy nearly two-thirds of the whole of the Great Northwest (Wang, 1940).

The climate here is the most rigorous, with very wide annual and daily ranges of air temperature. Schimper (1905) cites Przhevalsky's (1884) description of the climate of Gobi as follows: "Sharp contrast of temperature and extreme dryness characterize the local climate. Thus at  $42^{\circ}$  N. in southeastern Mongolia, at the end of November (1871), we noted a temperature of  $-32.7^{\circ}$  C. These severe night frosts lasted throughout winter and were prolonged into spring. On the other hand, during summer, in the same locality, we experienced an almost tropical heat, which is so much the more perceptible owing to the absence of forests and to the great atmospheric dryness. The temperature of the desert soil during summer rises to as much as  $50$  to  $60^{\circ}$  C., while in winter it sinks to  $-26.5^{\circ}$  C. and even lower. The transition between cold and heat both in spring and autumn are very sudden."

The mean air temperature of January varies from  $-5$  to  $-20^{\circ}$  C. and that of July from  $20$  to  $33^{\circ}$  C. The annual precipitation is very low, less than 100 mm. The annual precipitation in Chaklik is recorded only 4.5 mm.

Blizzards are extremely severe during winter and dangerous



to travelers. The strong winds start suddenly to drift the dry snow in appalling velocity but it stops as abruptly as it begins (Lattimore, 1929).

The vegetation in the desert areas is extremely poor. In contrast to most of the deserts in other parts of the world, there are very few semi-succulent xerophytes and a complete absence of succulent plants. The only semi-succulent plants growing in this region are: Zygophyllum xanthoxylum Maxim., Z. Loczyi Kanitz., Z. mucronatum Maxim., Peganum nigellastrum Bunge, P. harmala Linn., Nitraria Schoberi Linn. and N. Roborowskii Komarov. A few spiny or aphyllous shrubs, such as Ephedra monosperma C. A.Mey., Holorachne songarica Ehren., Alhagi Pseudoalhagi Desv., Haloxylon ammodendron Bunge, and Calligonum mongolicum Turcz., grow in certain more favorable localities.

A number of salt marshes are found along the salt lakes where Salicornia spp., Salsola spp., Suaeda spp., Triglochin maritimum Linn., Aster tripolium Linn., Aeluropus littoralis Parl., Juncus Thomsonii Tenore, Asparagus Mill., Glaux maritima Linn., Statice decipiens Ledeb. and Phragmites vulgaris Crepin (Liou, 1934).





## DISCUSSION

Pine seldom dominates climax formations as recognized in many countries, especially in the United States. However under certain circumstances, as where fires occur frequently, or on poor sites, the sub-climax pine forests can maintain themselves for a long time. Longleaf pine in the southeastern coastal plain and lodgepole pine in the western United States are examples. Similar situations have also been observed in China such as those involving Pinus insularis in Yunnan and P. densiflora in the Shantung Peninsula.

Moreover, pines which are dominant in successional communities may linger on individually in a climax formation of trees of other floristically different groups. In spite of the definite minor position in such climax formations, pines still lend a characteristic appearance to the vegetation because of their tall and distinctive growth habit. This is illustrated by the situation of white pine (Pinus strobus Linn.) in the eastern deciduous forest of the northeastern United States and loblolly and shortleaf pines in the oak-hickory climax formation in the southeastern states of this country. These lingering



pinus can supply seeds which may result in the establishment of pine reproduction on areas which have been rendered suitable by the destruction of the surrounding climax formation either natural or anthropological agencies.

Since pines are distinctive and bear cones either young or mature or both, throughout the year, tourists always notice them and botanists generally collect specimens even when in a great hurry. As a consequence, more records and specimens of pine are available than of any other groups of plants.

In China, the generic distribution of Pinus is almost throughout the whole country, wherever forest has been found. But on the other hand, regardless of such wide distribution of the genus, the number of species is relatively small in comparison with other widely distributed genera such as Quercus and Salix. This renders more feasible the use of its specific distribution as an indicator of natural forest regions. With such considerations in mind, based upon his extensive study of Chinese pines, the writer decided to classify the extremely complex forest vegetation of China with special reference to the natural distribution of pine.

Notwithstanding the advantages mentioned above, there are difficulties in classifying the whole forest vegetation of the country if the species ranges of pine are adhered to strictly. The difficulties, however, are really slight in dealing with such a complex problem, namely the classification of forest regions over such an extensive and varied country as China. All the difficulties have been solved satisfactorily.





As a matter of fact, three species of pine, Pinus tabulaeformis, P. Armandi and P. Bungeana, are distributed throughout North China except on the plains. The range covers almost two thousand kilometers from east to west and one thousand kilometers from north to south. The differences between types of major vegetation in the east and those in the west as well as their climatic and physiographic variations warrant the consideration of the whole area as one forest region. Actually, although these three species of pine occur almost throughout the whole range of mountains in North China, yet they are more common and continuous from the foothills up to the summits in the east and become locally limited and usually confined at lower altitudes in the west. In the east, the lowlands are loess basins which, judging from the prevailing climatic conditions, are the natural habitats of grassland rather than of forest. On the other hand, in the west, at higher elevations, there is sub-alpine and alpine vegetation and snow clad summits or ridges. Accordingly North China, excluding the plain, has been divided into two regions, namely the Loess Upland Woodland and Steppe, and the Northwestern Subalpine Boreal Forest.

Again, the three species of pine also occur in the Central Mountain Mixed Forest. But there are numerous southern species which can be used to distinguish this region readily from the other two regions just mentioned.

In South China, Pinus Massoniana is widely and abundantly distributed over almost half of the forest area of the whole country. Based upon the occurrence of three common bamboos--





Sinocalamus affinis, Phyllostachys edulis and Sinocalamus latifolius--this area has been divided into three regions, namely the Szechwan Basin Evergreen Forest, the Southern Yangtze Mixed Forest and the Southern Subtropical Monsoon Forest, each with its characteristic species of bamboo. These bamboos not only help in drawing boundaries of the three regions recognized, but they also indicate very effectively the climatic conditions of their respective regions. One can visualize the climatic conditions of these three regions by examining the growth habits of representative bamboos. It is clear that the time of the appearance of bamboo shoots is always preceded and accompanied by a rainy season. The rapid growth of the young shoots not only requires high rainfall but also warm temperature. In addition the late appearance of new shoots needs a milder winter otherwise they will be killed.

Two islands, Taiwan and Hainan, are most conveniently considered as separate regions. Although such consideration seems more or less artificial from the standpoint of plant sociology, yet the islands are physio-geographically natural units.

With the exception of the difficulties mentioned above, other forest regions are readily recognized by means of distribution of the pine species. They are: the Northeastern Boreal Mountain Forest (Pinus koraiensis), the Shantung Deciduous Forest (P. densiflora), the Southwestern Subalpine Boreal Forest (P. densata) and the Yunnan Upland Monsoon Forest (P. insularis).

Furthermore, within the Southern Yangtze Mixed Forest, two subregions are recognized and separated from the main region in



the lowland by means of the occurrence of two species of pine. In the southeastern coastal provinces, the mountains above 1,000 m. where Pinus luchuensis var. hwangshanensis occurs, is recognized as a subregion--the Southeastern Mountain Coniferous Forest. In the south of the Southern Yangtze Mixed Forest, the mountainous area where P. parviflora var. Fenzeliana occurs, is recognized as another subregion--the Southern Mountain Mixed Evergreen Forest.

The ecological succession of the forest vegetation in China, has been briefly mentioned in the text. As a general rule, in the deciduous forest area, oaks which are more tolerant, almost always play an important role in the climax formation. In transitional communities, birches and poplars frequently occupy a high percentage of the whole stand. However, they will eventually be replaced by more tolerant oaks. It is not uncommon for birches and poplars to form an edaphic climax. According to observations and reports, both beeches and hickory occupy only an insignificant position in deciduous forest in China. This is a great contrast to the conditions in the United States. There is only one species of hickory (Carya cathayensis Sarg.) which is extremely restricted in distribution. As to beech, there are five known species, namely Fagus Engleriana Seem., F. longipetiolata Seem., F. lucida Rehd. & Wils., F. Chienii Cheng and F. tienmoushanensis Liou. But none of them has special ecological significance.

In South China, wherever precipitation is abundant or soil moisture is available during most of the year, species of evergreen hardwoods are the important components of the climax





formation. Following the destruction of such evergreen hardwood forest, deciduous trees such as oaks, invade the denuded but not too seriously eroded area. These transitional forests of deciduous hardwoods will be replaced by evergreen hardwood species which are undoubtedly more tolerant. In case of severe denudation, the succession will start with herbaceous vegetation or even with lower plants. Among evergreen hardwoods, the species of Castanopsis and Lithocarpus attain prominent positions. However, species of Schima occasionally also play important roles in mixed forest or sometimes form pure stands of the climax as found in Szechwan and Yunnan.

There are quite extensive pine, bamboo and Cunninghamia lanceolata plantations in southeastern and southwestern China. Some of the bamboo and Cunninghamia lanceolata plantations are undoubtedly among the most intensively managed forests in the world. As mentioned above, in most cases, pine forest are usually of transitional stage, but in China because of frequent removal of the undergrowth for fuel, they are quite stable and can be properly regarded as dis-climax. Cunninghamia lanceolata has been observed to be more tolerant than Pinus Massoniana. As a consequence, the maintenance of Cunninghamia lanceolata plantations will be easier. Although there is little information regarding the natural forest stands of Cunninghamia lanceolata, it is quite possible that this tree once might have formed either pure stands or fairly extensive predominantly mixed stands. This has partially been confirmed by the excavation of large quantities of buried wood of this species in



eastern Sikang and central Hunan. With regard to bamboo, it is difficult to estimate its tolerance, which is an indication of successional trends. But since bamboos are under strict artificial control, there is no possibility for other plants to invade bamboo plantations and no natural succession.



## SUMMARY

In the present study, eighteen vegetational regions are recognized for the whole of China. Among the eighteen regions, twelve are regarded as forest regions based upon the fact that they are either mainly covered by forest vegetation or a considerable portion of the area should be devoted to forest plantations.

These twelve forest regions are determined primarily by the natural distribution of pines and other major plant communities. Accordingly, the distribution of pines is discussed separately under each region. For three forest regions in South China, namely the Szechwan Evergreen Forest, the Southern Yangtze Mixed Forest, and the Southern Subtropical Monsoon Forest, where only one species of pine, Pinus Massoniana, grows, three different species of bamboo are employed as indicators. Consequently, the distribution of these three bamboos, Sinocalamus affinis, Phyllostachys edulis and Sinocalamus latifolius, are specifically mentioned under each of the three regions. The two islands, Hainan and Taiwan, are considered as two independent regions due not to their distinct vegetation but to their clear-cut geographic isolation.





In addition to the distribution of pine and other plant communities, major environmental factors are described. The twelve forest regions recognized may be summarized as follows:

1. The Northeastern Boreal Forest. This is a rolling mountainous area with an altitude of 400 to 2,000 m. The mean air temperature of January ranges from  $-20$  to  $-28^{\circ}$  C. and that for July about  $20^{\circ}$  C. The annual precipitation varies from 400 to 500 mm. The soils are predominantly podzols. The major forest communities are mixed coniferous forests and mixed forests of both conifers and deciduous hardwoods. The pines represented in this region are: Pinus koraiensis, Pinus pumila and Pinus sylvestris var. siberica among which Pinus koraiensis is the characteristic species for the region.

2. The Shantung Deciduous Forest. The topography of this region is fairly rugged. It lies from the sea coast to 1,550 m. altitude. The mean air temperature for January is about 0 to  $-5^{\circ}$  C. and that of July 25 to  $30^{\circ}$  C. The annual precipitation varies from 500 to 1,000 mm. The soils are mainly Shantung brown soils. The forest communities are deciduous hardwoods. Pinus densiflora is the only representative of the genus here.

3. The Central Mountain Mixed Forest. This is a mountainous country with a few basins along rivers. The altitudinal range of this region ranges between 700 to 3,000 m. The mean air temperature for January is about zero, and that of July ranges from 22 to  $28^{\circ}$  C. The annual precipitation varies from 600 to 1,000 mm. The main soil types are gray-brown soils and yellow earths. The deciduous hardwoods and the pine forests are the major forest communities in this region. There are



some fir and spruce forests on high mountains. The pines indigenous here are Pinus tabulaeformis, P. Armandi, P. Bungeana and P. Henryi.

4. The Western Subalpine Boreal Forest. This region consists mainly of rolling mountains and rugged towering peaks. The elevation ranges from 1,500 to 3,500 m. The mean air temperature of January is about  $-3$  to  $-5^{\circ}$  C. and that of July is 18 to  $20^{\circ}$  C. The annual precipitation varies from 500 to 700 mm. The dark chestnut soils predominate in the forest area. Pure spruce forests and mixed forests of spruce and fir are major forests of commercial importance. However, deciduous hardwoods and pine forests are more widespread. Species of pine represented are: P. tabulaeformis, P. Armandi and P. Bungeana.

5. The Southwestern Subalpine Forest. This is a vast conglomeration of peaks and mighty gorges with very little level land. The range in elevation is extremely wide, from 1,000 to 4,500 m. The mean air temperature of January varies from 0 to  $-5^{\circ}$  C., and that of July about  $15^{\circ}$  C. The annual precipitation amounts to 1,000 to 2,000 mm. Gray-brown soils are the most important soil types. Fir and spruce forests constitute the majority of the forest. Pinus densata is the representative of the region. In low valleys Pinus insularis and P. Armandi occur sporadically.

6. The Szechwan Evergreen Forest. Except the Chengtu plain, the region comprises a group of rolling or rugged hills and mountains, with elevations ranging from 450 to 2,500 m. The mean air temperature of January is about  $5^{\circ}$  C. and that of





July 25° C. The annual precipitation varies from 1,000 to 1,200 mm. Young purple soils cover most of the area. Important forest communities in this region are semi-sclerophyllous evergreen forests, deciduous hardwoods, and pine or cypress forests. Pinus Massoniana grows extensively and is widely planted. Sinocalamus affinis is the characteristic bamboo here.

7. The Southern Yangtze Mixed Forest. This is a quite rugged region with a number of alluvial fans and delta. The elevation ranges from 50 to 1,000 m. Above 1,000 m. altitude, two subregions are recognized.

The mean air temperature of January is about 2 to 10° C. and that of July is approximately 30° C. The annual precipitation ranges from 1,000 to 2,000 mm. Red earths, yellow earths and gray-brown soils are the important types of soils. Within the region plantations of bamboo, pine and Cunninghamia lanceolata are common. Deciduous forests and sclerophyllous evergreen forest are also widespread. Pinus Massoniana is the only indigenous pine. Phyllostachys edulis is the characteristic bamboo for the region.

Above 1,000 m. two subregions are recognized. One is named as the Southeastern Mountain Coniferous Forest, which is characterized by the presence of Pinus luchuensis var. hwangshanensis and the other is named as the Southern Mountain Mixed Forest which is characterized by P. parviflora var. Fenzeliana.

8. The Southern Subtropical Monsoon Forest. This is the area of rolling hills and with a few higher mountain peaks.



The elevation is mostly from sea level up to 400 m. The mean air temperature of January rarely sinks below 10° C. and that of July is about 28° C. The annual precipitation varies from 1,500 to 2,000 mm. Red earths predominate the whole region. The important forest communities here are sclerophyllous evergreen forests, deciduous hardwoods and pine forest and plantation. Pinus Massoniana is the representative species of pine here. Sinocalamus latifolius is the characteristic bamboo for the region.

9. The Yunnan Upland Monsoon Forest. This is a mountainous upland. The elevation is mostly above 2,000 m. The mean air temperature of January is about 9° C. and that of July 20° C. The annual precipitation ranges from 1,000 to 1,500 mm. The important types of soils are red earths, purple soils and gray-brown soils. The region is mostly covered by pure pine forests or pine and Keteleeria Davidiana mixed forests. There are also sclerophyllous evergreen forest and deciduous forests in certain places. The region is extensively covered by the characteristic pine, Pinus insularis.

10. The Hainan Subtropical Forest. This is an isolated island. The topography is rather flat with rolling hills and a few towering peaks. The majority of island lies below 700 m. The mean air temperature of January is about 17° C. and that of July 28° C. The annual precipitation ranges from 1,200 to 1,500 mm. Red earths and yellow earths are the major types of soil. In the lowland, savannah forests predominate, whereas on higher mountains, evergreen forests become important. There





are three species of pines--P. Massoniana, P. parviflora var. Fenzeliana and P. Merkusii.

11. The Taiwan Forest. This is a mountainous island. The elevation ranges from sea level up to 3,500 m. The mean air temperature of February (the coldest month) is 12 to 20° C. and that of July about 28° C. The precipitation is fairly high ranging from 1,000 to 2,500 mm. annually. Red earths, yellow earths and gray-brown soils and podzols are important forest soils. There are different types of forests on the island, namely mangrove-like forest, coastal woodlands, evergreen hardwood forest, evergreen coniferous forest and subalpine woodlands. The evergreen hardwood and evergreen coniferous forests are of paramount importance economically. There are five species of pine: Pinus luchuensis, P. parviflora var. morrisonicola, P. Armandi var. morrisonicola and P. Massoniana.

12. The Loess Upland Steppe and Woodland. This region consists of rolling mountains and eroded basins. The elevation ranges from 500 to 2,500 m. The mean air temperature of January varies from -5 to -15° C. and that of July 22 to 28° C. The precipitation amounts within the range of 350 to 700 mm. Light chestnut soils and dark chestnut soils are important soil types. On the mountain, deciduous hardwoods and pine forests are major plant communities. Grasslands should be chief vegetation in the lowlands. Three species of pine are found: Pinus tabulaeformis, P. Bungeana and P. Armandi.

Six other regions are regarded as non-forested areas. They are: the Northeastern Plain, the Great Northern Plain, the





Yangtze River-Lacustrine Plain, the Tibetain Plateau, the Northwest Grassland and the Sinkiang-Mongol Desert. In these regions trees grow or are planted only in certain spots. Although they do not form extensive forests, the limited amount of the arborescent vegetation in these non-forested areas is of paramount importance to human life, as trees or shrubs will not only supply practical needs for wood products but also make the environment more agreeable for human habitation.



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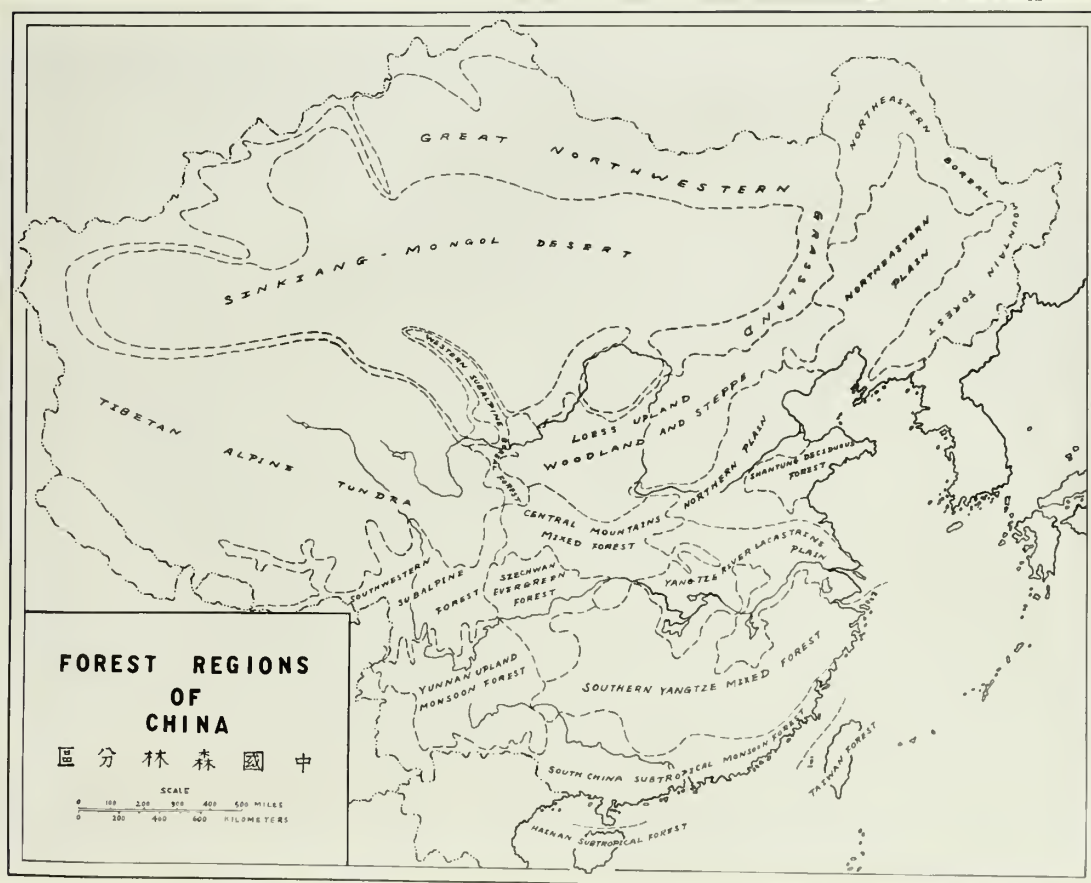
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MAP I  
FOREST REGIONS OF CHINA









AUTOBIOGRAPHY--Chung-lwen Wu





## Autobiography--Chung-Lwen Wu

The writer was born at Chuchi, Chekiang, China, August 27, 1913.

### Education

Completed the courses in the elementary schools.

High school diploma from the Chekiang Provincial High School 1933.

Bachelor of Agriculture degree, University of Nanking, China, 1941.

Master of Forestry, Yale University, 1947.

Yale University, 1947-1948, one year.

Duke University, 1948-1949, one year.

### Scientific Organizations

Science Society of China, 1933-1936.

### Positions

Botanic Collector, Science Society of China, 1933-1936.

Assistant, University of Nanking, 1941-1942.

Technician, Department of Agriculture and Forestry, China, 1942-1945.

Instructor, Yunnan University, 1945-1946.













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